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RADIOACTIVE RELEASE DATA FROM CANADIAN NUCLEAR GENERATING STATIONS 1972 TO ~~1988~~ 1989

Compiled by
Radiation Protection Division
Atomic Energy Control Board
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Report

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Introduction

All nuclear generating stations emit small quantities of radioactive effluent both into the atmosphere and, in the form of liquid effluent, into the adjoining water body, be it river, lake or sea. The purpose of this document is to report on the magnitude of these emissions for each nuclear generating station in Canada and to indicate how these emissions compare with the relevant limitations imposed by the Atomic Energy Control Board as part of its regulatory and licensing program.

This is the fourth edition of this report. It incorporates histograms indicating the annual releases of tritium in air, noble gases, iodine-131, airborne particulate, tritium in water and waterborne gross beta activity for each nuclear generating station. In addition, for Pickering NGS "A", annual releases of Carbon-14 are depicted for the years 1986, 1987 and 1988, and for Darlington NGS, airborne emissions of both tritium oxide (HTO) and elemental tritium (HT) are shown. In each case the emission data are compared to the Derived Emission Limit (DEL) (see later for an explanation of this term) in order that the data may be placed in perspective. At present, only Pickering NGS "A" is required to monitor and report Carbon-14 emissions. Environmental monitoring for C-14 is conducted around the Bruce site to determine the environmental impact of its emission and whether effluent monitoring will be necessary in future years. Darlington NGS is required to monitor and report airborne emissions of both HTO and HT as a result of the operation of the Tritium Removal Facility (TRF) that is located there.

Three nuclear generating stations have been permanently taken out of service during the last few years (Gentilly NGS-1, Douglas Point NGS and NPD NGS). Some small emissions from Douglas Point and NPD do still occur however, as a result of decontamination and decommisioning operations. The small quantities of liquid waste emanating from Gentilly 1 are pumped to Gentilly 2 and these emissions are included with the routine effluent of Gentilly 2.

Derived Emission Limits

Radioactive material emitted from nuclear generating stations into the atmosphere or into an adjoining water body can result in radiation dose to members of the public as a result of direct irradiation, inhalation of contaminated air or ingestion of contaminated food or water. Such doses are limited by statutory dose limits for members of the public. These are set out in Schedule II of the Atomic Energy Control Regulations and are reproduced in Table 1 below:

Table 1

ORGAN OR TISSUE	ANNUAL DOSE LIMIT FOR MEMBERS OF THE PUBLIC
Whole Body, Gonads, Red Bone Marrow	5 mSv (0.5 rem)
Skin, Bone, Thyroid	30 mSv (3 rem) (50% of this value for children)
Extremities	75 mSv (7.5 rem)
Other single organs or tissues	15 mSv (1.5 rem)

The magnitude of the doses to which members of the public might normally be exposed as a result of routine emissions from nuclear generating stations are too low to allow direct measurement to determine compliance with these regulations. Instead, the emissions themselves are limited to levels such that those groups within the population that, as a result of their location, age, life-style etc. will probably receive the highest dose for a particular radionuclide and mode of release, do not exceed a small fraction of the relevant annual dose limit. Such groups are termed 'critical groups', and these can be defined for different radionuclides and modes of release.

The limits governing the planned release of radionuclides are called Derived Emission Limits (DELs), (also referred to as Derived Release Limits (DRLs). They are set after consideration of all pathways by which releases of radioactive material can contribute to the radiation dose of individual members of the public to ensure that doses to members of the critical group do not exceed the limits indicated above. As a result of the uncertainty regarding many of the transfer parameters that are used in mathematical models, conservatism is built into the calculation of each DEL. Therefore the annual dose limits will be respected as long as the annual releases do not exceed their respective DELs. Because of this conservatism, estimates of individual doses to members of the public by prorating actual releases as a function of the DEL will result in overestimates. As new information becomes available, the values of the DELs may be revised. The current DELs for all Canadian Nuclear Generating Stations are listed in Table 2.

At present, nuclear generating stations maintain an operating target such that emissions not exceed 1% of each DEL. As the following data indicate, for the most part this operating target is achieved. Although DELs are expressed on an annual basis, the

rate of emission is controlled by limiting airborne emissions to 1% of the weekly DEL (i.e., DEL/52) and by limiting waterborne emissions to 1% of the monthly DEL (i.e., DEL/12).

Authorized Limits

In addition to the DEL's the Atomic Energy Control Board sometimes imposes authorized limits which are less than the DEL. For instance, during the construction stage of a multi-unit station when not all the units are yet operational, the DEL may be prorated by the number of units currently operational.

Authorized emission limits significantly lower than the DELs have sometimes been imposed during the decommissioning stage of reactors. For the purposes of this report however, only the DEL established by the methods outlined earlier have been used as a comparison with actual releases.

Release Data

Licensees measure and report their releases in different ways. Some have established DELs and report actual releases for a wide variety of fission and activation products, while others report the major contributors such as tritium, iodine-131 and noble gases and combine the rest under the title of gross-beta activity, using the most restrictive nuclide of the remainder as the basis for the DEL. In this report, all station release data have been expressed in the same terms. These are:

Airborne Mode:	tritium, iodine-131, noble gases and miscellaneous particulates
Waterborne Mode:	tritium, gross-beta activity

In addition, as a result of a specific licence requirement, Pickering "A" has been reporting carbon-14 releases since 1986, and Darlington NGS is reporting both tritium oxide (HTO) and elemental tritium (HT) commencing in 1988, as a result of the operation of the Tritium Removal Facility (TRF) located there.

Tables 3-11 shows the annual release of each radionuclide expressed in both absolute terms and as a percentage of the relevant DEL for each nuclear generating station. The absolute values are expressed in terabecquerels (TBq), except for noble gases (1TBq = 10^{12} Bq = 27 curies). Since noble gases are inert and do not interact with the human body, one can estimate the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

TABLE 2

	DERIVED EMISSION LIMITS FOR GASEOUS EFFLUENTS (1)					DERIVED EMISSION LIMITS FOR LIQUID EFFLUENTS (1)		
	Tritium	Iodine 131	Noble Gases	Particulate	Carbon 14	Tritium	Gross Beta	Carbon 14
Bruce NGS "A"	3.9×10^5	3.3	8.3×10^4	8.3	-	5.3×10^5	28	-
Bruce NGS "B"	6.2×10^5	3.3	4.4×10^5	8.3	-	5.3×10^5	28	-
Pickering NGS "A" (2)	2.7×10^5 (3.8×10^5).	4.2 (0.8).	1.0×10^5 (0.87×10^5).	10.8 (1.9).	2.7×10^3	6.2×10^5	33	-
Pickering NGS "B"	2.7×10^5	4.2	1.0×10^5	10.8	-	6.2×10^5	33	-
Point Lepreau NGS	1.6×10^6	2.6	3.6×10^5	7.8	-	4.7×10^7 (3)	113	-
Gentilly 2 NGS	3.5×10^5	1.7	8.1×10^4	4.6	-	1.6×10^5	8.9	-
Darlington NGS (4)	2.1×10^5 (1.4×10^8).	0.6	2.1×10^5	4.4	1.3×10^3	5.3×10^6	133	3.2×10^3
Douglas Point NGS (5)	1.5×10^6	6	2.9×10^5	14	-	3.5×10^5	2	-
NPD NGS (6)	6.7×10^5	11.5	1.5×10^5	29	-	9.8×10^4	5.3	-
Gentilly 1 NGS (7)	1.0×10^6	3.5	4.6×10^4	8.6	-	9.0×10^4	4.9	-

NOTES

(1) All units are in TBq (1TBq=27Ci) except for noble gases. Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

(2) At the time that Pickering NGS "B" emission limits were derived, the DELs for Pickering NGS "A" were reviewed. The result was that new DELs for airborne emissions apply as of January 1983. The values applicable before 1983 are shown in parentheses. DELs for liquid emissions remain unchanged.

(3) The DEL for tritium in liquid effluent at Point Lepreau is much higher than for other stations. This is because the effluent goes to salt water and hence drinking water is not a pathway to man.

(4) Darlington NGS is due to start operation during 1989. Note also that for this station a DEL has been approved for tritium gas (in parentheses) in addition to the normal gaseous tritium oxide effluent. This is for the control of effluents from the tritium removal facility that is located at Darlington NGS.

(5) Douglas Point NGS was shut down in 1984 and is currently being decommissioned. Authorized limits for liquid release were in effect for 1986, 1987 and 1988. These were: 2.7×10^3 TBq for tritium and 0.15 TBq for gross beta.

(6) NPD NGS was shutdown in 1987 and is currently being decommissioned.

(7) Gentilly 1 NGS has been in a permanent shut down state since April 1986.

Radioactive Emission Data

for

Operating Nuclear Generating Stations

TABLE 3

Annual Activity Emitted in Gaseous Effluents from Bruce NGS "A" (4 units)

Year	Tritium DEL = 3.9×10^5 TBq TBq emitted	% of DEL	Iodine 131 DEL = 3.3 TBq TBq emitted	% of DEL	Noble Gases DEL = 8.3×10^4 TBq-MeV TBq-MeV emitted	% of DEL	Particulate DEL = 8.3 TBq TBq emitted	% of DEL
1976	46	0.01	7.80×10^{-7}	<0.01	9	0.01	3.20×10^{-6}	<0.01
1977	314	0.08	4.60×10^{-4}	0.01	1440	1.74	9.20×10^{-5}	<0.01
1978	500	0.13	1.10×10^{-4}	<0.01	1554	1.88	1.37×10^{-4}	<0.01
1979	1400	0.36	5.00×10^{-4}	0.02	3000	3.63	1.30×10^{-4}	<0.01
1980	1600	0.42	1.30×10^{-4}	<0.01	830	1.00	5.70×10^{-5}	<0.01
1981	3400	0.88	1.00×10^{-4}	<0.01	610	0.74	9.50×10^{-5}	<0.01
1982	1500	0.39	1.20×10^{-3}	0.04	510	0.62	8.90×10^{-5}	<0.01
1983	3848	1.00	3.66×10^{-4}	0.01	673	0.81	5.00×10^{-5}	<0.01
1984	2500	0.65	2.80×10^{-3}	0.09	800	0.97	5.90×10^{-5}	<0.01
1985	1481	0.39	4.62×10^{-5}	<0.01	789	0.95	2.89×10^{-4}	<0.01
1986	1809	0.47	1.04×10^{-4}	<0.01	558	0.67	4.04×10^{-4}	<0.01
1987	2116	0.55	6.35×10^{-5}	<0.01	519	0.63	7.50×10^{-4}	<0.01
1988	2120	0.55	6.54×10^{-5}	<0.01	500	0.60	1.00×10^{-3}	0.01

Annual Activity Emitted in Liquid Effluents from Bruce NGS "A"

Year	Tritium DEL = 5.3×10^5 TBq TBq emitted	% of DEL	Gross Beta DEL = 28 TBq TBq emitted	% of DEL
1976	1	<0.01	<0.01	<0.01
1977	36	<0.01	0.02	0.08
1978	153	0.03	0.18	0.64
1979	550	0.10	0.21	0.75
1980	900	0.17	0.16	0.57
1981	740	0.14	0.08	0.29
1982	970	0.18	0.08	0.29
1983	1598	0.30	0.07	0.25
1984	600	0.11	0.07	0.26
1985	1066	0.20	0.09	0.32
1986	1376	0.26	0.12	0.43
1987	1110	0.21	0.05	0.17
1988	1550	0.29	0.13	0.48

START UP YEAR FOR BRUCE NGS "A" WAS 1976

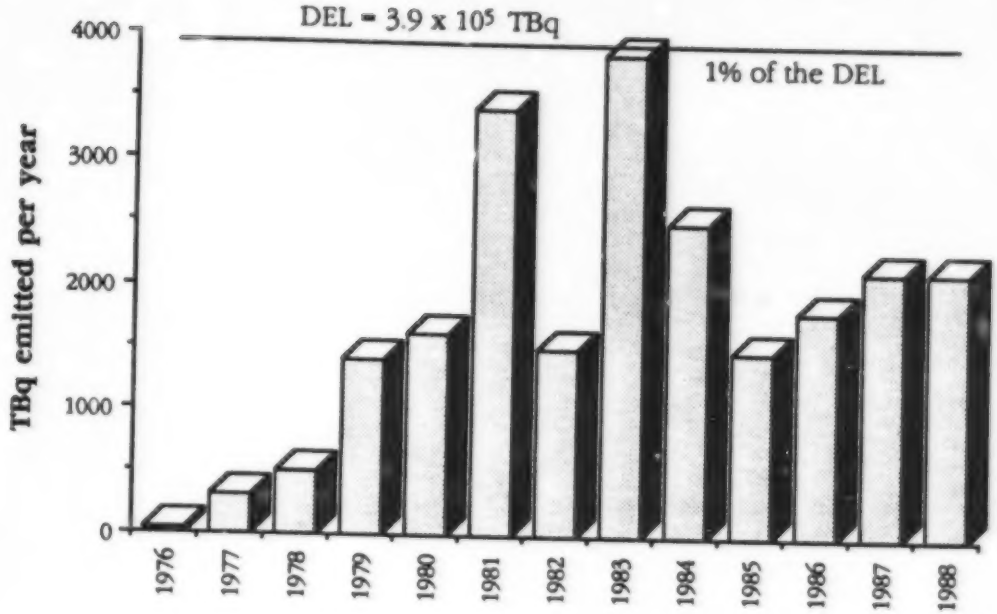
NOTES

(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

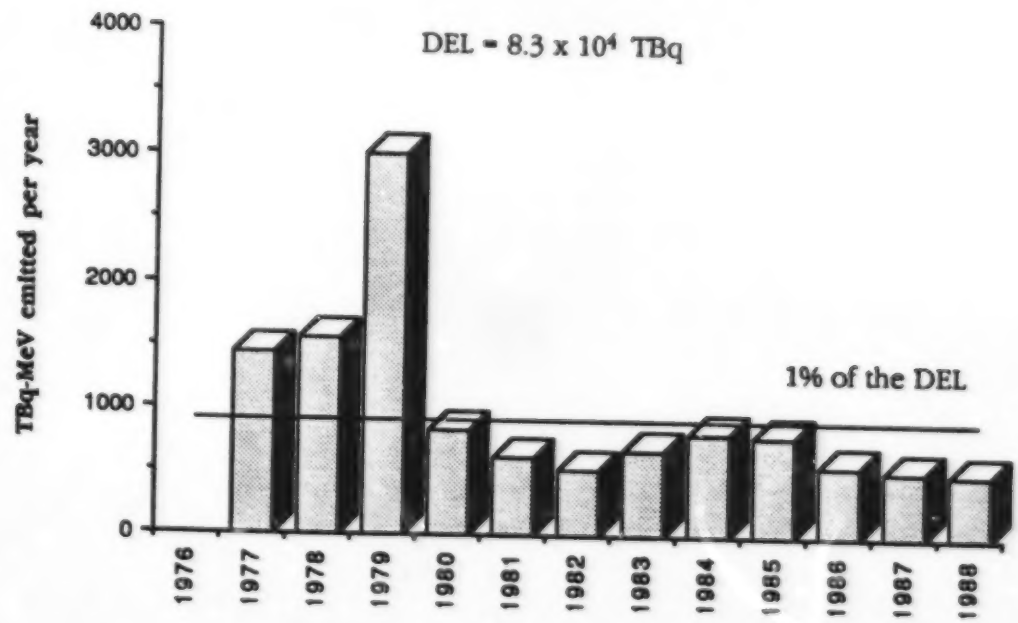
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

Bruce NGS "A"
Airborne releases of Tritium and Noble Gases

Tritium



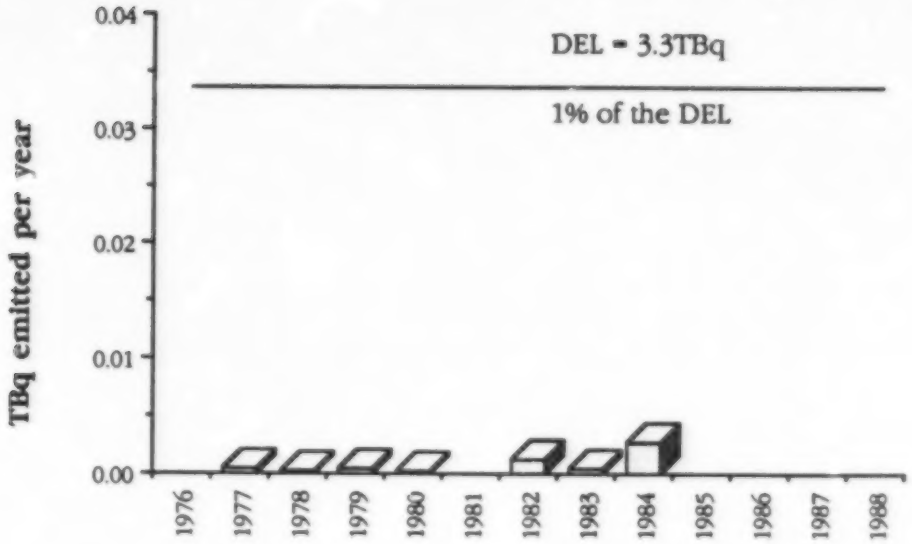
Noble Gases



Bruce NGS "A"

Airborne releases of Iodine 131 and Radioactive Particulate

Iodine 131



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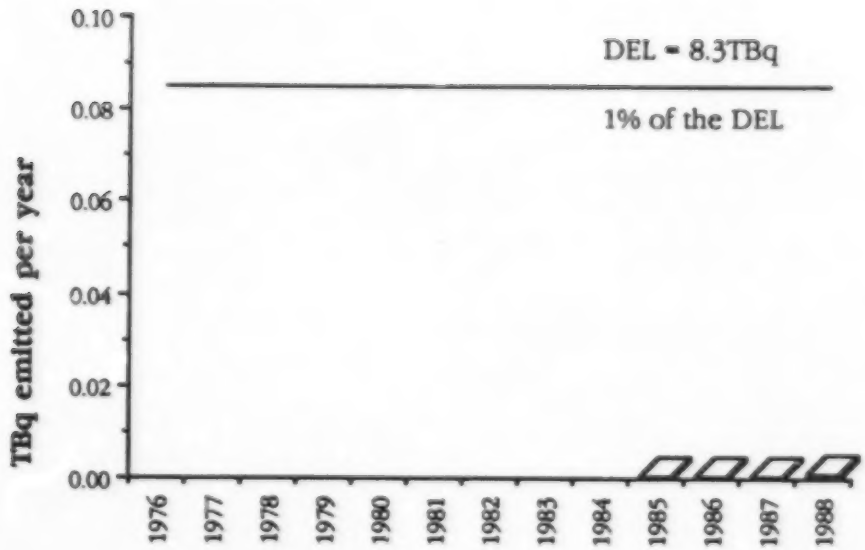
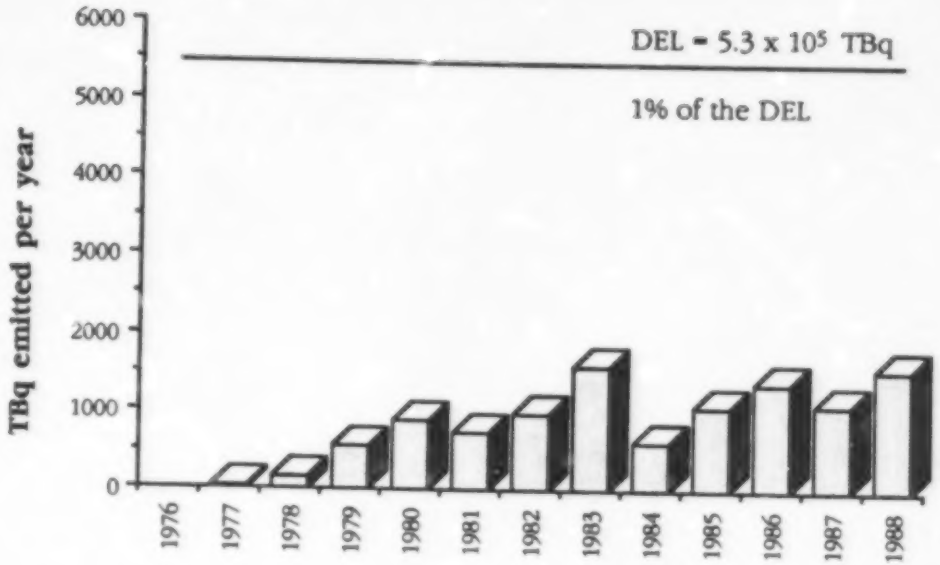


Bruce NGS "A"
Liquid releases of Tritium and Gross Beta Activity

Tritium



Gross Beta Activity

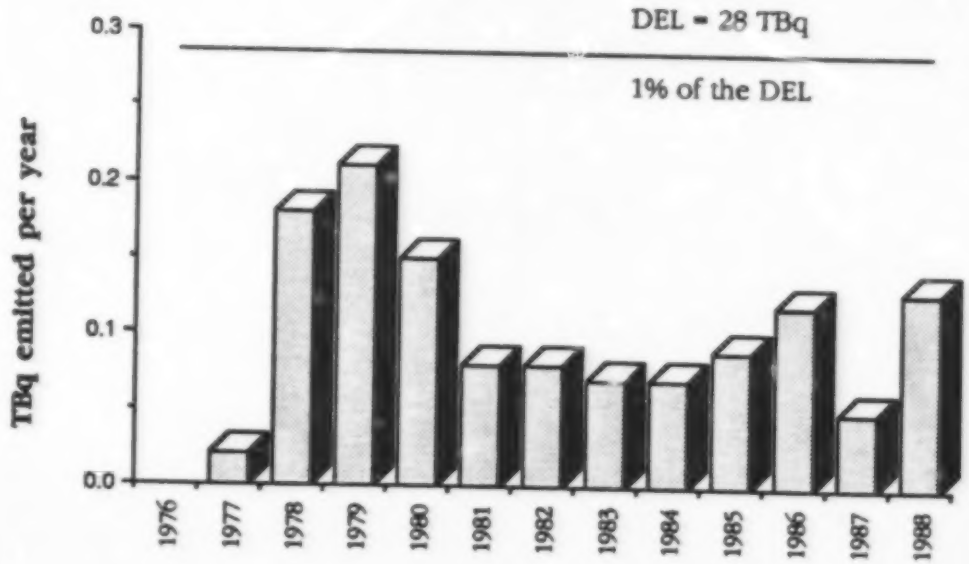


TABLE 4

Annual Activity Emitted in Gaseous Effluents from Bruce NGS "B" (4 units)

Year	Tritium DEL = 6.2×10^5 TBq		Iodine 131 DEL = 3.3 TBq		Noble Gases DEL = 4.4×10^5 TBq-MeV		Particulate DEL = 8.3 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL	TBq-MeV emitted	% of DEL	TBq emitted	% of DEL
1984	3	<0.01	4.40×10^{-6}	<0.01	29	<0.01	1.20×10^{-4}	<0.01
1985	98	0.02	5.20×10^{-5}	<0.01	106	0.02	2.12×10^{-4}	<0.01
1986	164	0.03	6.16×10^{-5}	<0.01	127	0.03	3.46×10^{-4}	<0.01
1987	462	0.08	9.24×10^{-5}	<0.01	139	0.03	2.50×10^{-4}	<0.01
1988	480	0.08	9.8×10^{-5}	<0.01	154	0.04	1.65×10^{-4}	<0.01

Annual Activity Emitted in Liquid Effluents from Bruce NGS "B"

Year	Tritium DEL = 5.3×10^5 TBq		Gross Beta DEL = 28 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL
1984	1	<0.01	0.007	0.02
1985	21	<0.01	0.007	0.02
1986	93	0.02	0.013	0.04
1987	102	0.02	0.003	0.01
1988	210	0.04	0.008	0.03

START UP YEAR FOR BRUCE NGS "B" WAS 1984

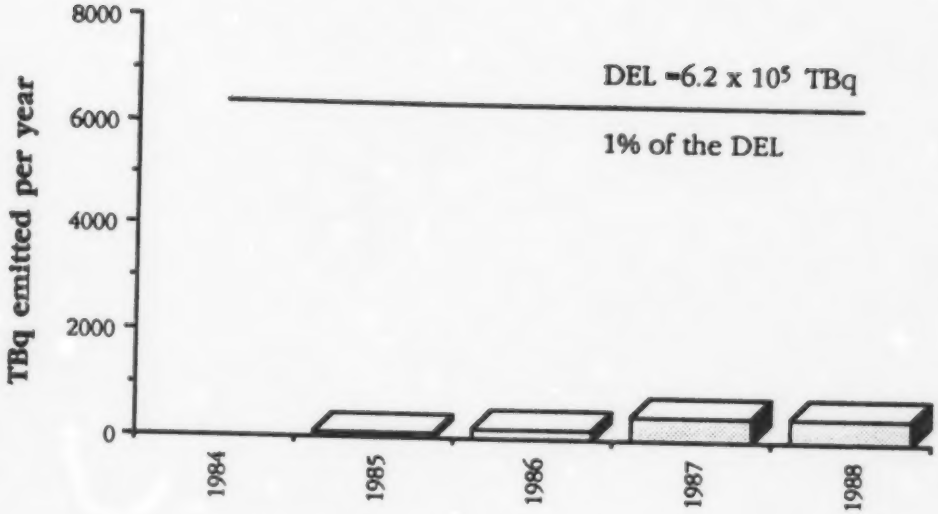
NOTES

(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

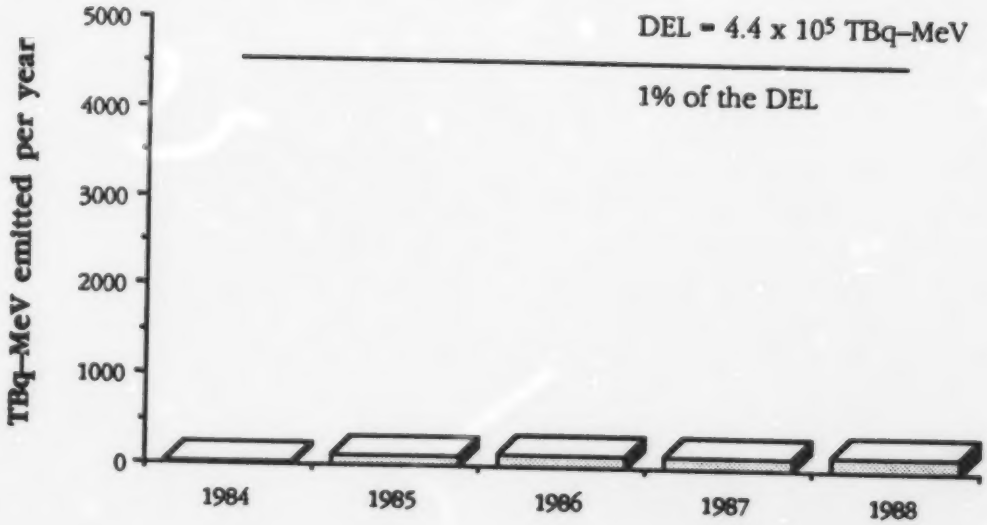
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

Bruce NGS "B"
Airborne releases of Tritium and Noble Gases

Tritium



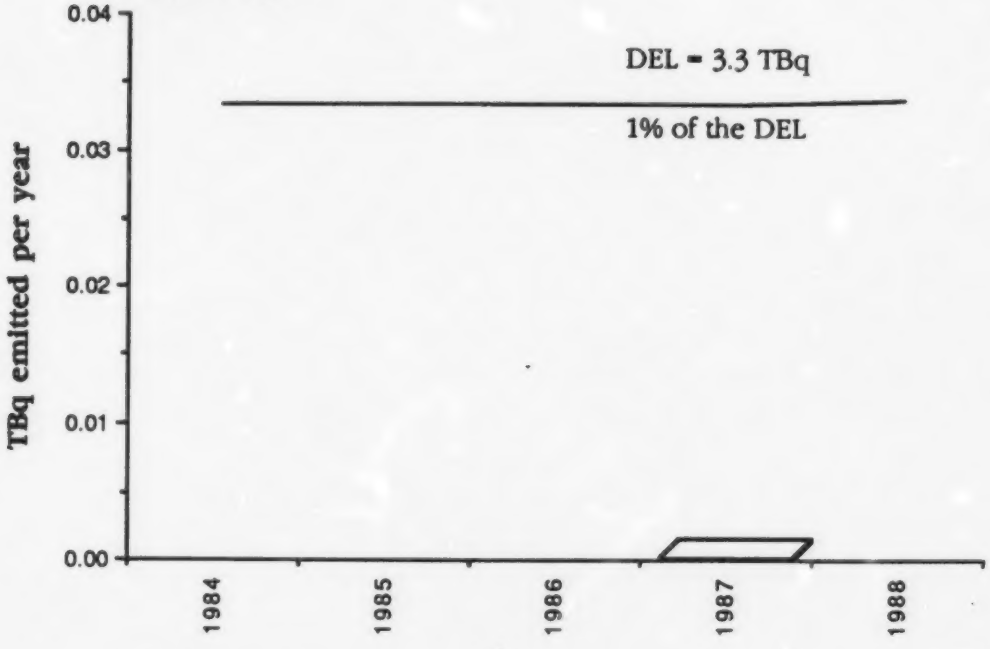
Noble Gases



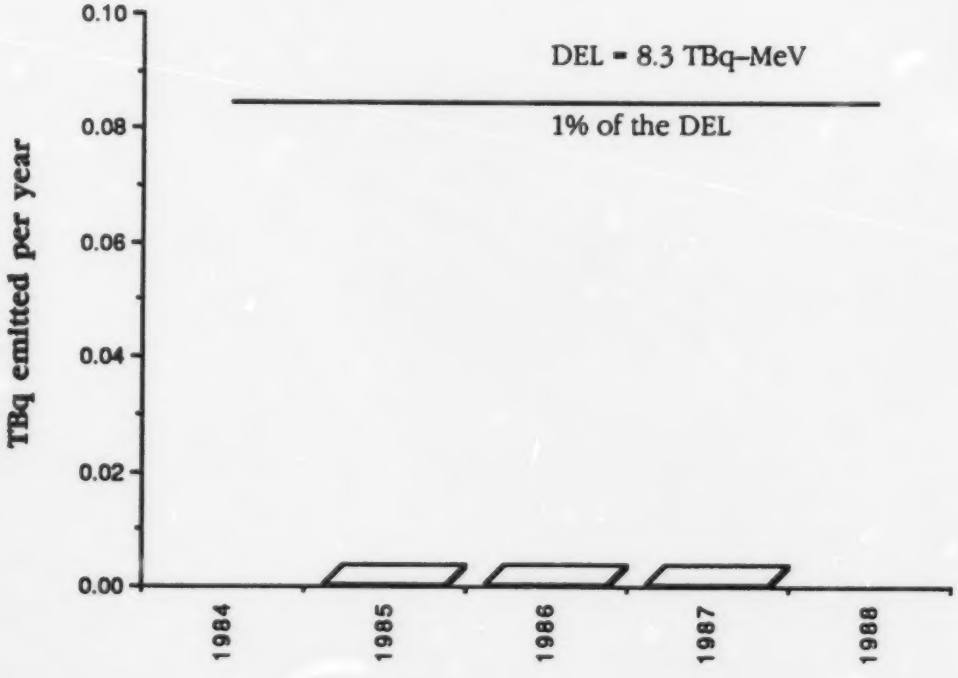
Bruce NGS "B"

Airborne releases of Iodine 131 and Radioactive Particulate

Iodine 131

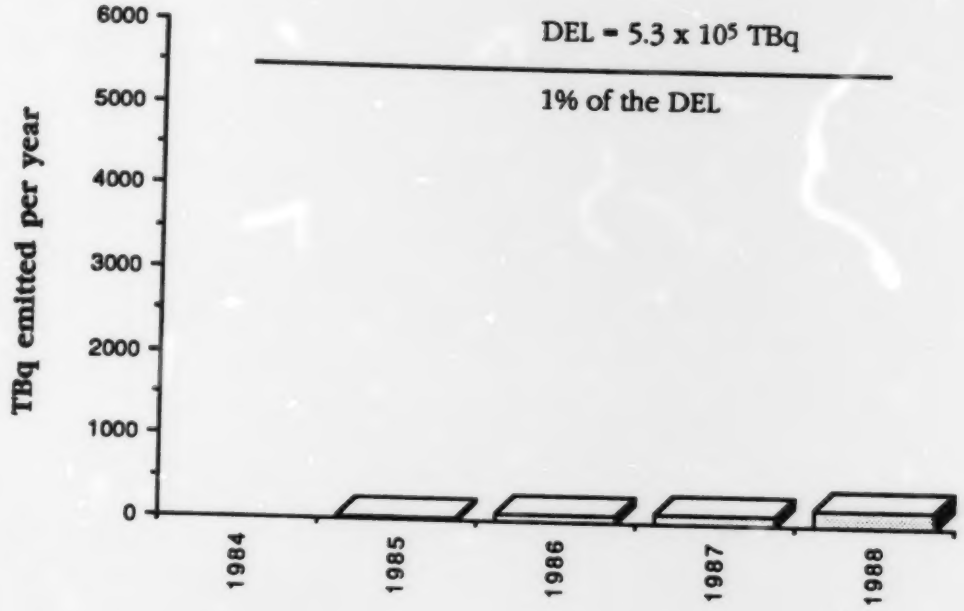


Particulate



Bruce NGS "B"
Liquid releases of Tritium and Gross Beta Activity

Tritium



Gross Beta Activity

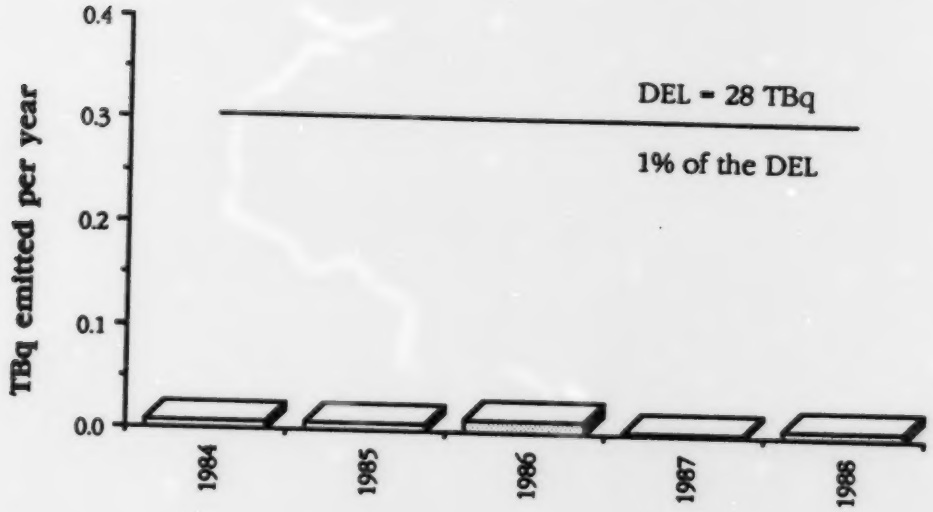


TABLE 5

Annual Activity Emitted in Gaseous Effluents from Pickering NGS "A" (4 units)

Year	Tritium DEL = 2.7×10^5 TBq (3.8×10^5 TBq before 1983) TBq emitted	% of DEL see note(3)	Iodine 131 DEL = 4.2 TBq (0.8 TBq before 1983) TBq emitted	% of DEL see note(3)	Noble Gases DEL = 1.0×10^5 TBq-MeV (0.87×10^5 TBq-MeV before 1983) TBq-MeV emitted	% of DEL see note(3)	Particulate DEL = 10.8 TBq (1.9 TBq before 1983) TBq emitted	% of DEL see note(3)	Carbon-14 DEL = 2700 TBq TBq emitted	% of DEL
1972	530	0.14	4.9×10^{-3}	0.61	1860	2.14	5.00×10^{-4}	0.03		
1973	1400	0.37	2.0×10^{-4}	0.03	1500	1.72	4.10×10^{-4}	0.02		
1974	920	0.24	1.5×10^{-4}	0.02	160	0.18	1.40×10^{-3}	0.07		
1975	760	0.2	4.1×10^{-5}	0.01	190	0.22	2.70×10^{-4}	0.01		
1976	895	0.24	5.6×10^{-5}	0.01	104	0.12	1.54×10^{-4}	<0.01		
1977	1630	0.43	7.0×10^{-5}	0.01	159	0.18	2.66×10^{-4}	0.01		
1978	960	0.25	5.6×10^{-5}	0.01	150	0.17	1.10×10^{-4}	<0.01		
1979	1150	0.3	7.8×10^{-5}	0.01	220	0.25	4.10×10^{-5}	<0.01		
1980	680	0.18	1.6×10^{-4}	0.02	240	0.28	1.20×10^{-4}	<0.01		
1981	580	0.15	6.3×10^{-5}	0.01	250	0.29	1.70×10^{-4}	<0.01		
1982	680	0.18	6.9×10^{-5}	0.01	220	0.25	1.70×10^{-4}	<0.01		
1983	635	0.24	6.9×10^{-5}	0.00	212	0.20	1.92×10^{-5}	<0.01		
1984	430	0.16	6.2×10^{-5}	<0.01	174	0.17	2.10×10^{-5}	<0.01		
1985	385	0.14	5.6×10^{-5}	<0.01	192	0.18	2.69×10^{-4}	<0.01		
1986	346	0.13	6.7×10^{-5}	<0.01	183	0.18	1.08×10^{-3}	0.01	13.3	0.49
1987	654	0.24	1.2×10^{-4}	<0.01	289	0.28	1.06×10^{-3}	<0.01	13.0	0.48
1988	962	0.36	8.5×10^{-4}	0.02	233	0.23	8.14×10^{-4}	<0.01	11.8	0.44

Annual Activity Emitted in Liquid Effluents from Pickering NGS "A"

Year	Tritium DEL = 6.2×10^5 TBq TBq emitted	% of DEL	Gross Beta DEL = 33 TBq TBq emitted	% of DEL
1972	40	<0.01	0.1	0.30
1973	190	0.03	0.067	0.20
1974	540	0.09	0.096	0.29
1975	390	0.06	0.037	0.11
1976	220	0.04	0.03	0.09
1977	700	0.11	0.03	0.09
1978	1200	0.19	0.03	0.09
1979	1400	0.23	0.037	0.11
1980	470	0.08	0.013	0.04
1981	280	0.05	0.008	0.02
1982	370	0.06	0.018	0.05
1983	324	0.05	0.022	0.07
1984	343	0.06	0.027	0.08
1985	333	0.05	0.032	0.10
1986	84	0.01	0.020	0.06
1987	444	0.07	0.023	0.07
1988	592	0.10	0.023	0.07

START UP YEAR 1971

The dose limits apply to Pickering NGS "A" and "B" separately and accordingly separate DELs have been calculated.

NOTES

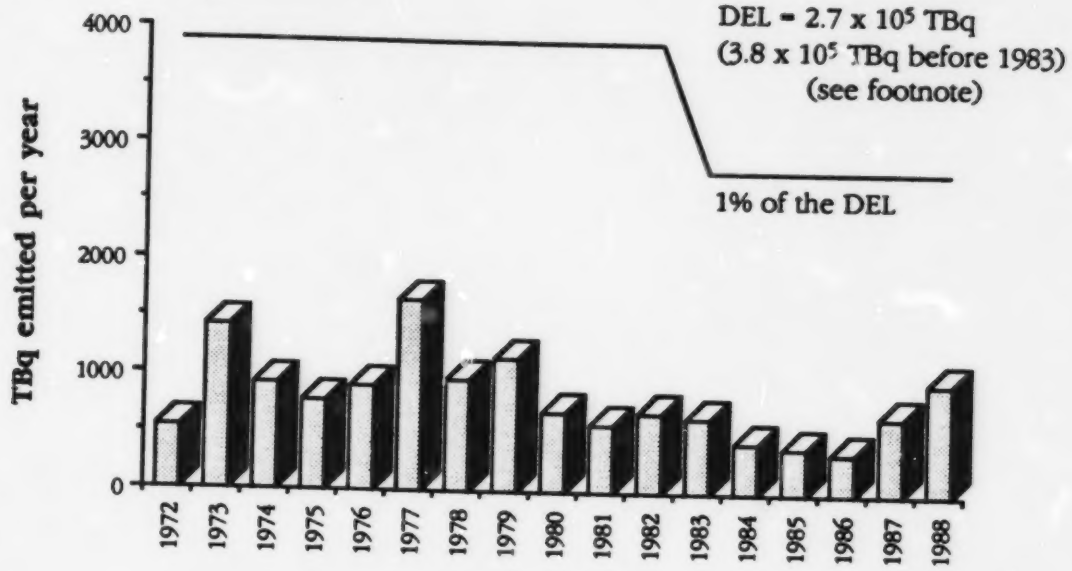
(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

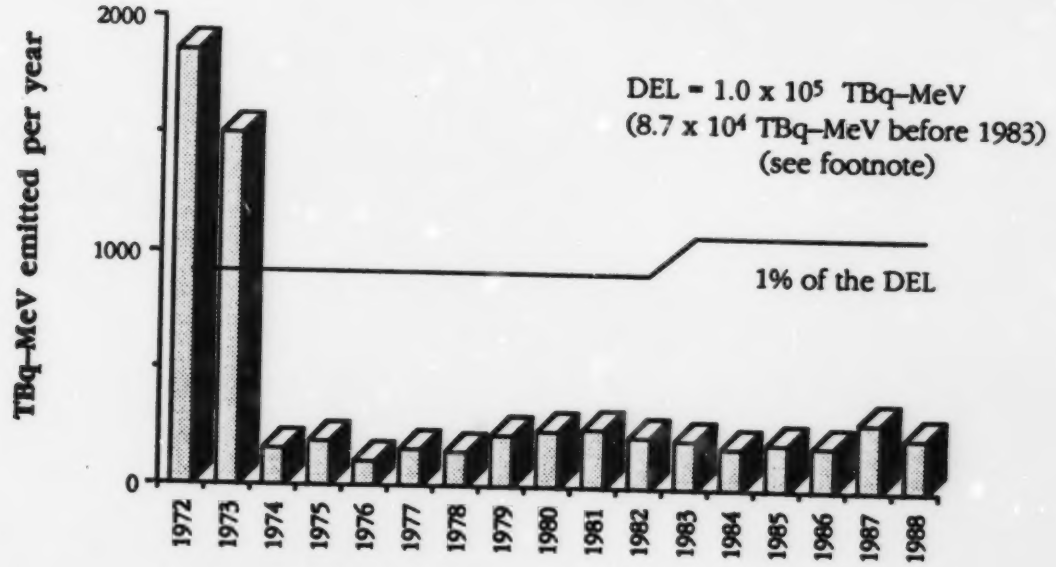
(3) At the time that Pickering NGS"B" emission limits were derived, the DELs for Pickering NGS"A" were reviewed. The result was that new DELs for airborne emission apply as of January 1983 (see diagram). The DELs for liquid emissions remain unchanged.

Pickering NGS "A"
Airborne releases of Tritium and Noble Gases

Tritium in air



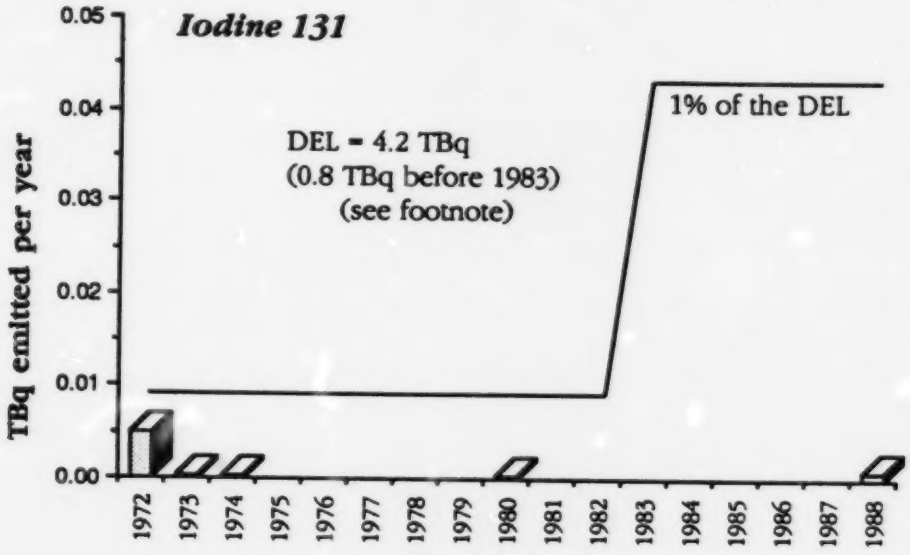
Noble Gases

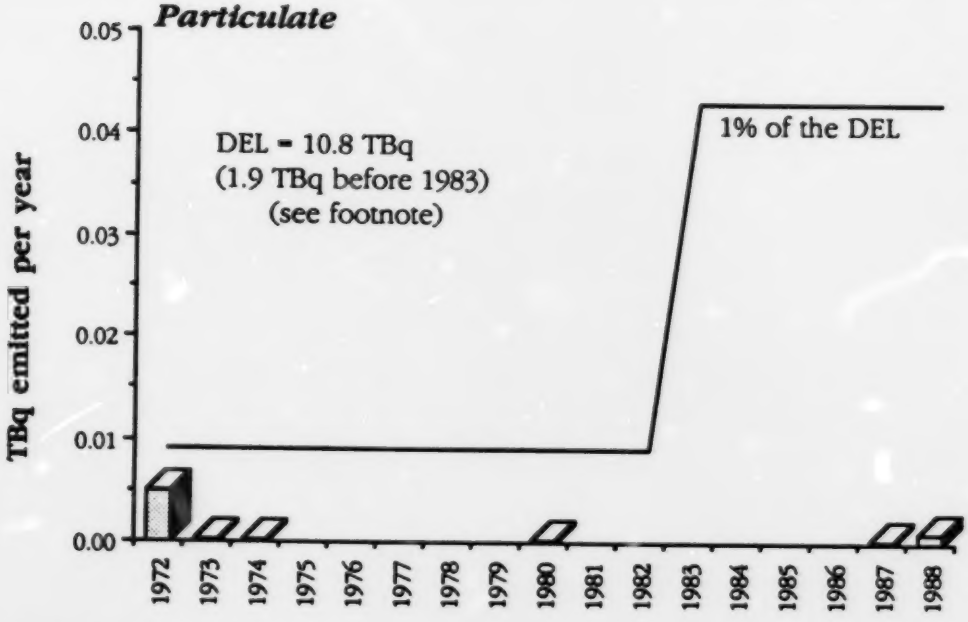


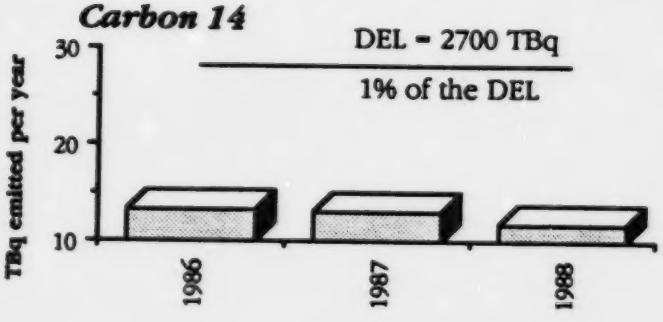
At the time that the Pickering NGS"B" emission limits were derived, the DELs for Pickering NGS"B" were reviewed. The result was that new DELs for airborne emission apply as of January 1983. The DELs for liquid emissions remain unchanged.

Pickering NGS "A"

Airborne releases of Iodine 131, Radioactive Particulate and Carbon 14



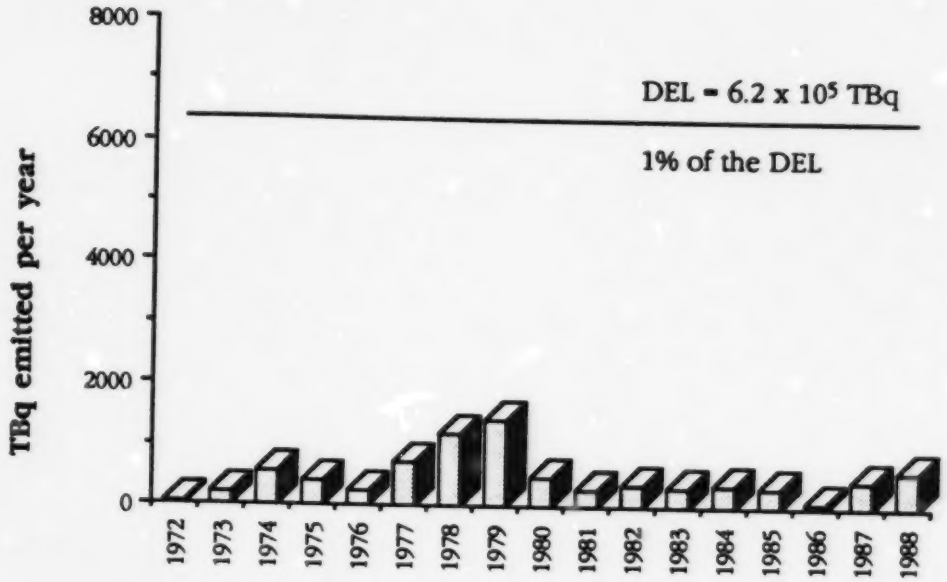




At the time that the Pickering NGS"B" emission limits were derived, the DELs for Pickering NGS"B" were reviewed. The result was that new DELs for airborne emission apply as of January 1983. The DELs for liquid emissions remain unchanged.

Pickering NGS "A"
Liquid releases of Tritium and Gross Beta Activity

Tritium in liquid



Gross Beta Activity

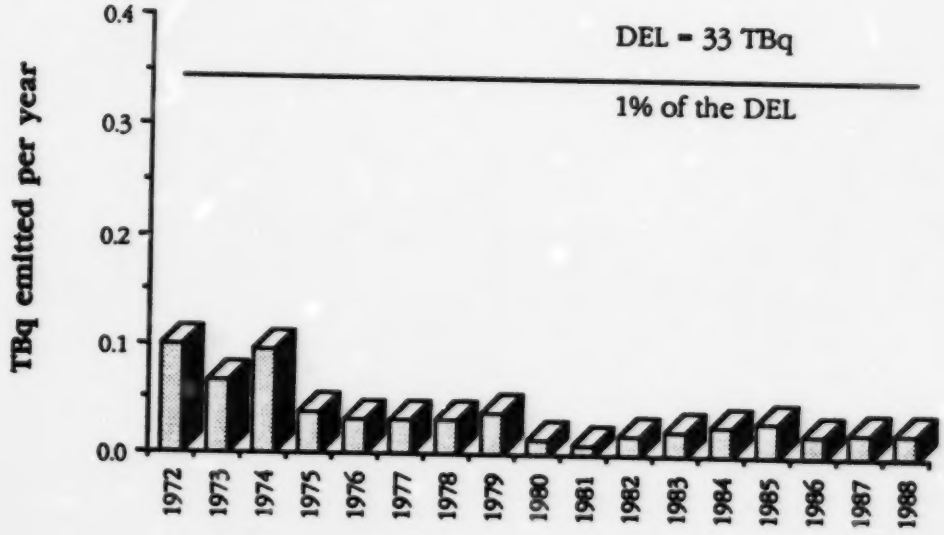


TABLE 6

Annual Activity Emitted in Gaseous Effluents from Pickering NGS "B"

Year	Tritium DEL = 2.7×10^5 TBq		Iodine 131 DEL = 4.2 TBq		Noble Gases DEL = 1.0×10^5 TBq-MeV		Particulate DEL = 10.8 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL	TBq-MeV emitted	% of DEL	TBq emitted	% of DEL
1983	21	0.01	5.96×10^{-5}	<0.01	137	0.13	8.081×10^{-6}	<0.01
1984	46	0.02	1.57×10^{-4}	<0.01	167	0.16	1.184×10^{-5}	<0.01
1985	144	0.05	4.43×10^{-5}	<0.01	175	0.17	1.289×10^{-5}	<0.01
1986	187	0.07	6.54×10^{-5}	<0.01	269	0.26	1.558×10^{-5}	<0.01
1987	231	0.09	5.19×10^{-5}	<0.01	231	0.22	1.52×10^{-5}	<0.01
1988	196	0.07	7.03x10-5	<0.01	215	0.21	1.41×10^{-5}	<0.01

Annual Activity Emitted in Liquid Effluents from Pickering NGS "B"

Year	Tritium DEL = 6.2×10^5 TBq		Gross Beta DEL = 33 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL
1983	44	0.01	0.01	0.07
1984	74	0.02	0.03	0.14
1985	377	0.08	0.01	0.03
1986	844	0.14	0.02	0.07
1987	1687	0.27	0.02	0.05
1988	1073	0.17	0.06	0.18

START UP YEAR FOR PICKERING NGS "B" WAS 1982

The dose limits apply to Pickering NGS "A" and "B" separately and according separate DELs have been calculated.

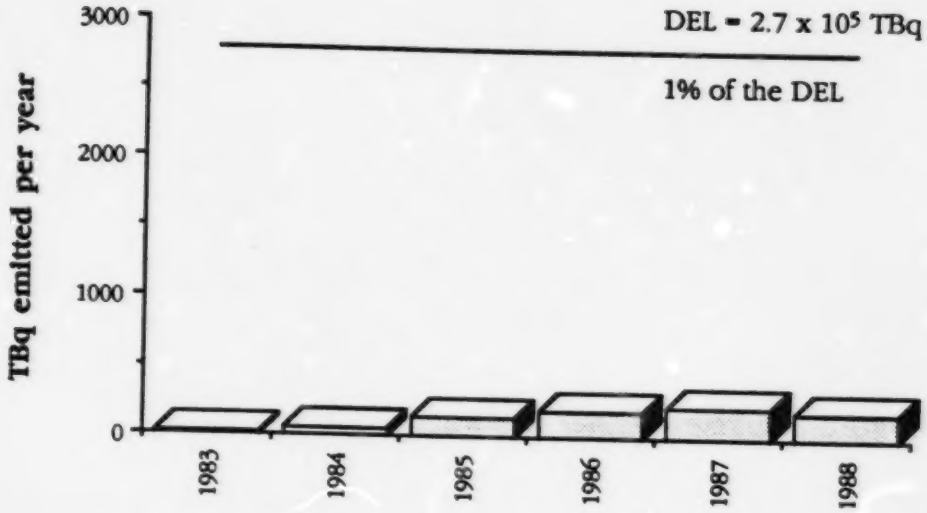
NOTES

(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

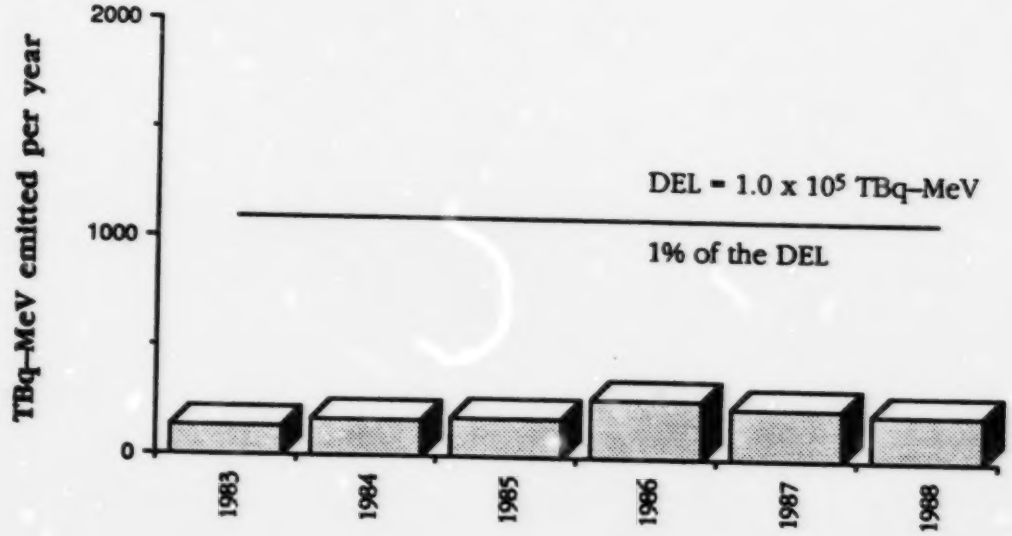
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitte percentage of the DEL.

Pickering NGS "B"
Airborne releases of Tritium and Noble Gases

Tritium in air

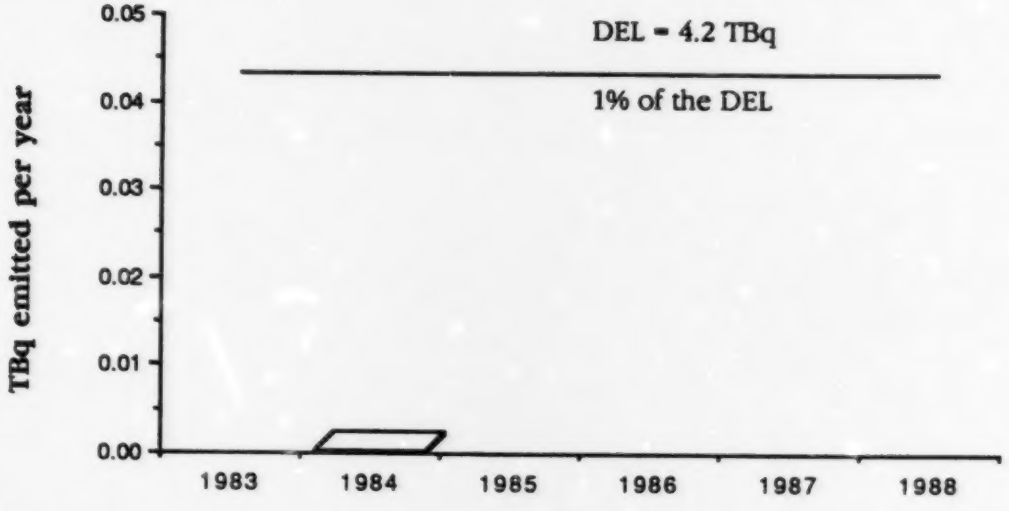


Noble Gases

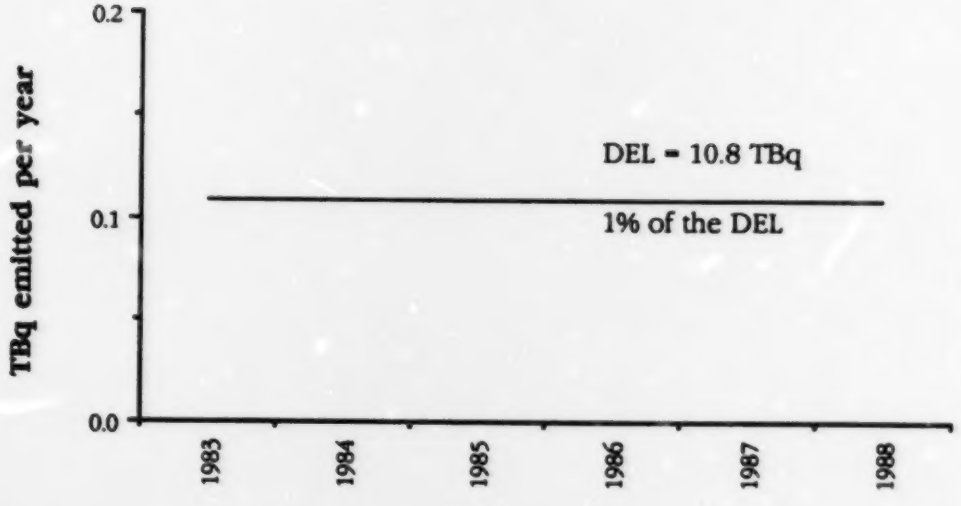


Pickering NGS "B"
Airborne releases of Iodine 131 and Radioactive Particulate

Iodine 131

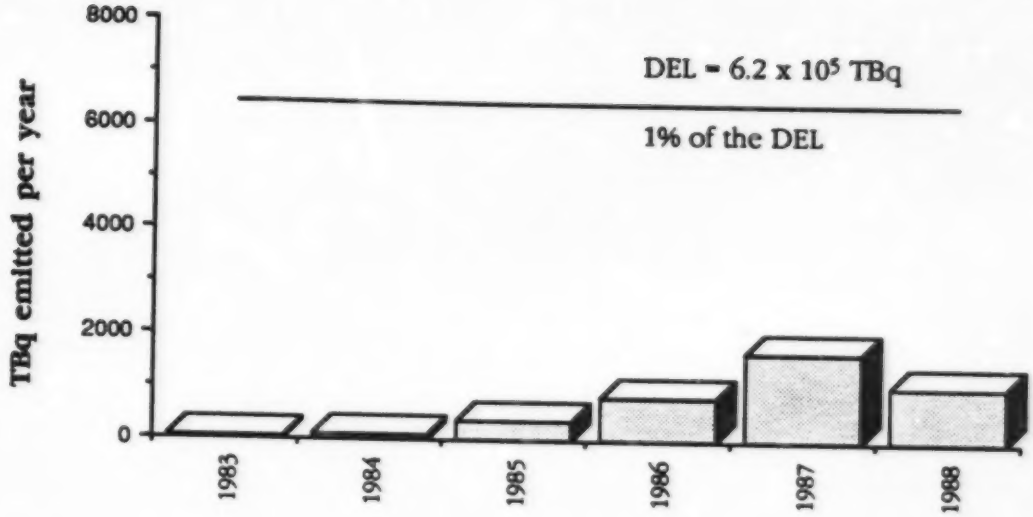


Particulate



Pickering NGS "B"
Liquid releases of Tritium and Gross Beta Activity

Tritium



Gross Beta Activity

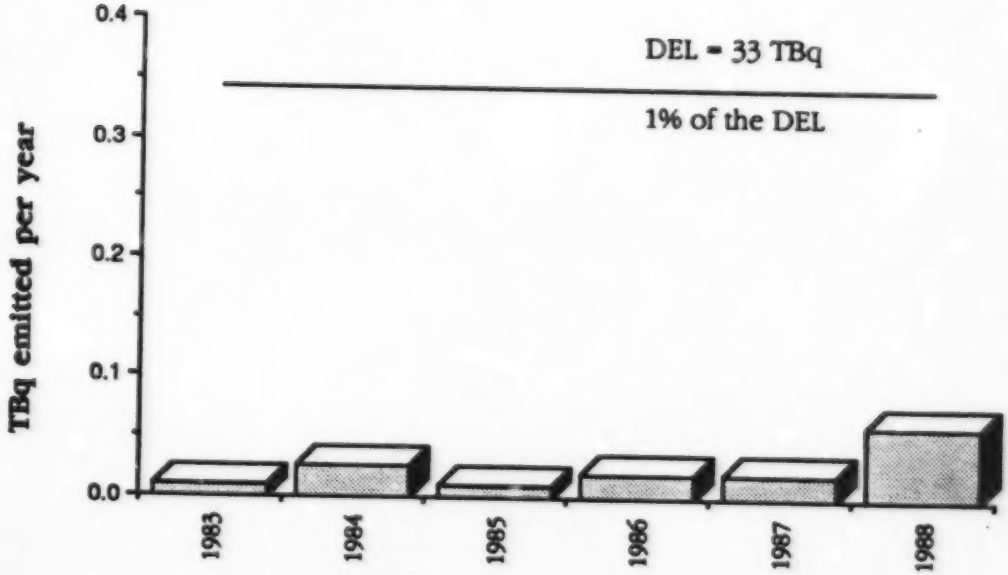


TABLE 7

Annual Activity Emitted in Gaseous Effluents from Pt. Lepreau NGS

Year	Tritium DEL = 1.6×10^{6} TBq		Iodine 131 DEL = 2.6 TBq		Noble Gases DEL = 3.6×10^{5} TBq-MeV		Particulate DEL = 7.8 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL	TBq emitted	% of DEL	TBq emitted	% of DEL
1982	0	<0.01	ND	<0.01	0.1	<0.01	ND	<0.01
1983	25	<0.01	9.60×10^{-6}	<0.01	0.1	<0.01	ND	<0.01
1984	68	<0.01	ND	<0.01	0.0	<0.01	ND	<0.01
1985	110	0.01	4.20×10^{-6}	<0.01	0.8	<0.01	ND	<0.01
1986	200	0.01	2.90×10^{-5}	<0.01	5.0	<0.01	ND	<0.01
1987	220	0.01	ND	<0.01	0.1	<0.01	ND	<0.01
1988	220	0.01	5.05×10^{-5}	<0.01	0.3	<0.01	ND	<0.01

NOTE: ND means Not Detected

Annual Activity Emitted in Liquid Effluents from Point Lepreau NGS

Year	Tritium DEL = 4.7×10^{7} TBq (see note (3))		Gross Beta DEL = 113 TBq (see note (3))	
	TBq emitted	% of DEL	TBq emitted	% of DEL
1982	0.5	<0.01	1.7×10^{-5}	<0.01
1983	9	<0.01	3.0×10^{-3}	<0.01
1984	68	<0.01	1.3×10^{-2}	0.01
1985	24	<0.01	1.6×10^{-3}	<0.01
1986	110	<0.01	1.1×10^{-3}	<0.01
1987	96	<0.01	4.2×10^{-4}	<0.01
1988	120	<0.01	1.9×10^{-3}	<0.01

START UP START UP YEAR 1982

NOTES

(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

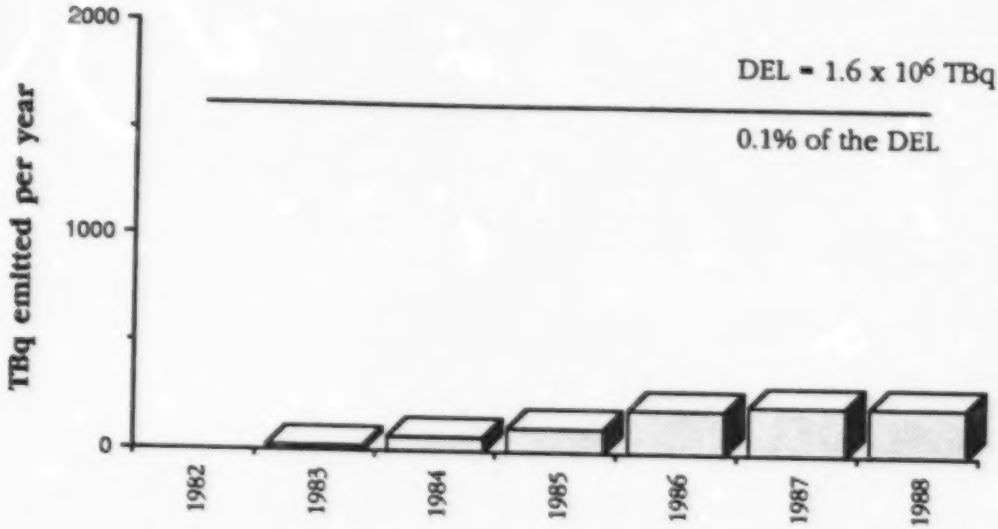
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

(3) The DEL for tritium in liquid effluent at Point Lepreau is much higher than for other stations. This is because the effluent goes to salt water and hence drinking water is not a pathway to man.

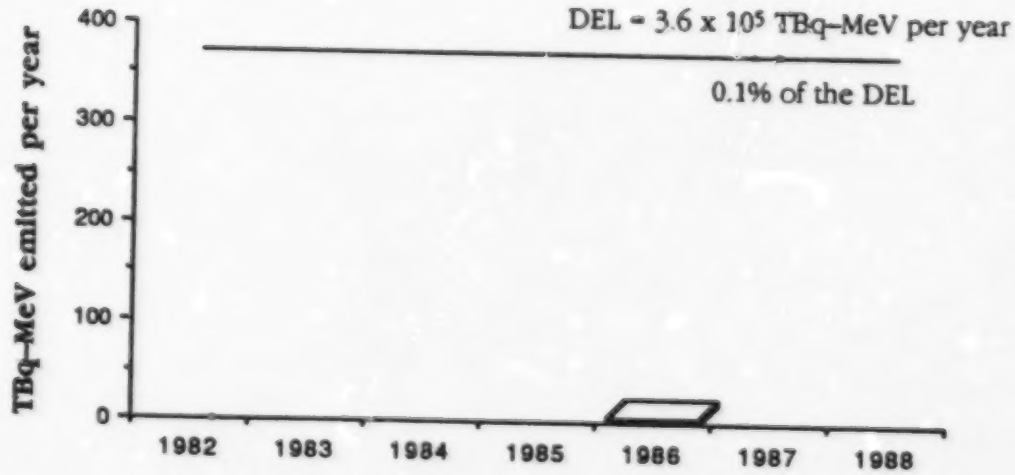
Point Lepreau NGS
Airborne releases of Tritium and Noble Gases

Note: Since all emissions to date from Point Lepreau NGS have been very low relative to the respective DEL's, all histograms of emission data are plotted relative to 0.1% of the DEL (instead of 1% as is done for the other nuclear generating stations).

Tritium



Noble Gases

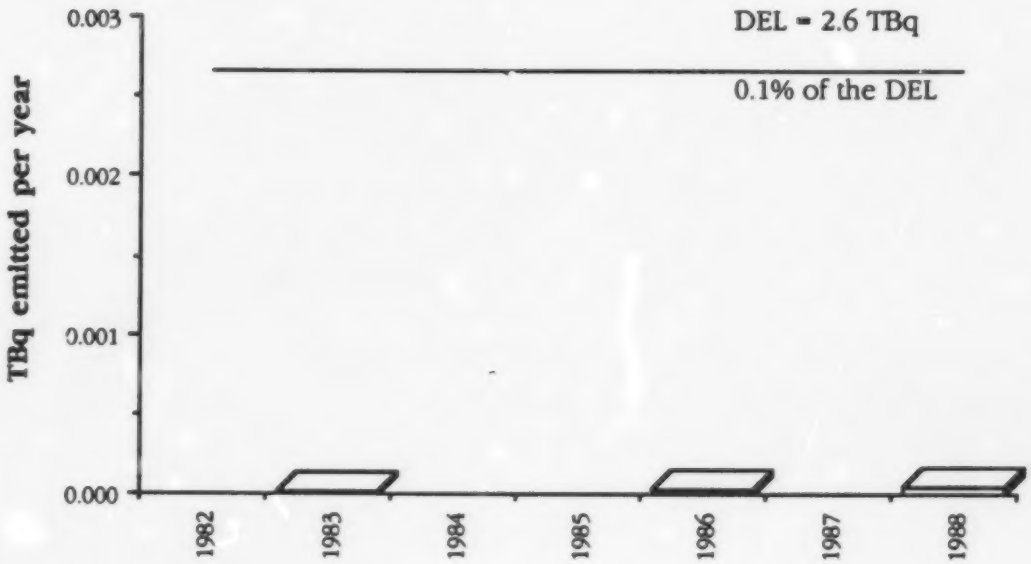


Point Lepreau NGS

Airborne releases of Iodine 131 and Radioactive Particulate

Note: Since all emissions to date from Point Lepreau NGS have been very low relative to the respective DEL's, all histograms of emission data are plotted relative to 0.1% of the DEL (instead of 1% as is done for the other nuclear generating stations).

Iodine 131



Particulate

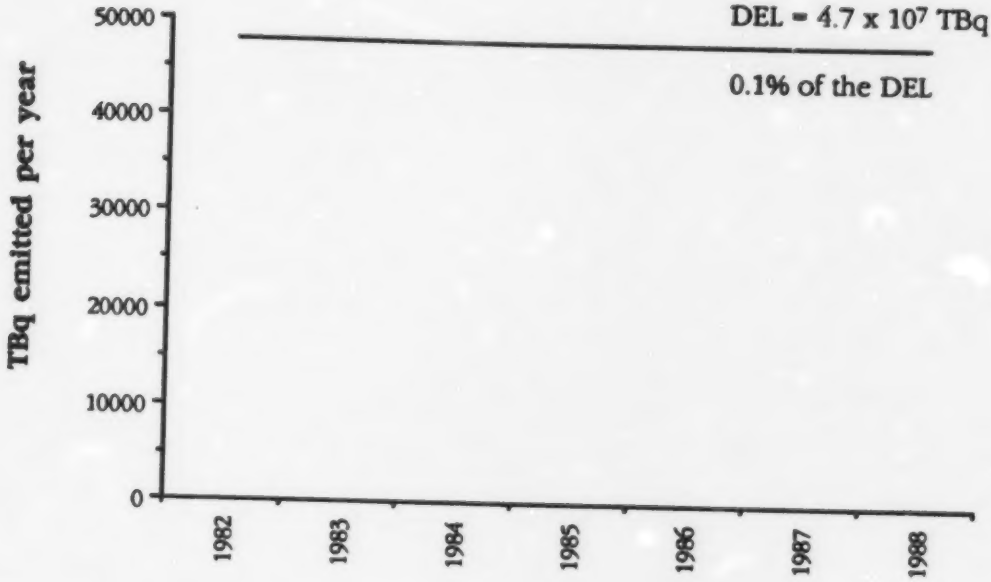
DEL = 7.8 TBq

No radioactive particulate has yet been detected in the gaseous effluent of Point Lepreau NGS.

Point Lepreau NGS
Liquid releases of Tritium and Gross Beta Activity

Note: Since all emissions to date from Point Lepreau NGS have been very low relative to the respective DEL's, all histograms of emission data are plotted relative to 0.1% of the DEL (instead of 1% as is done for the other nuclear generating stations).

Tritium



Gross Beta

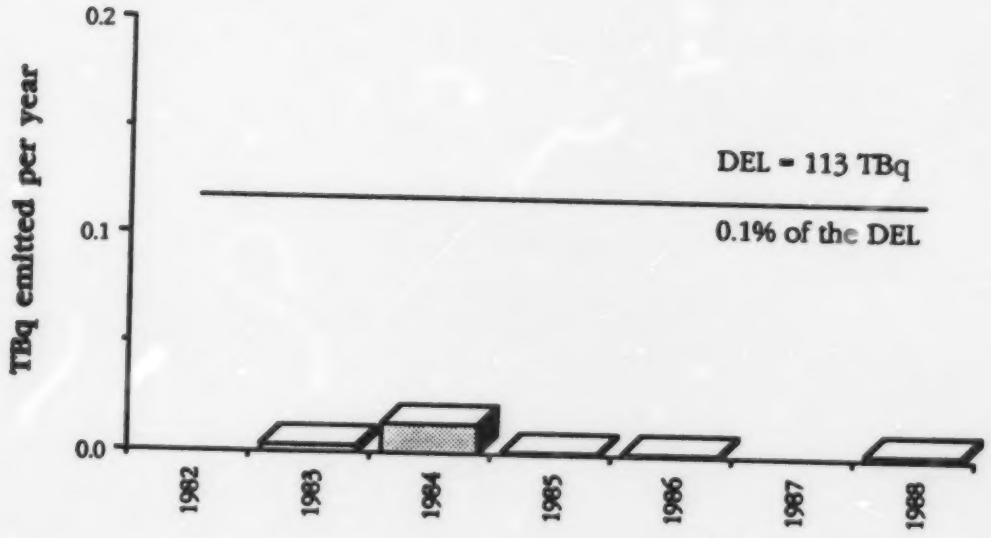


TABLE 8

Annual Activity Emitted in Gaseous Effluents from Gentilly 2 NGS

Year	Tritium DEL = 3.5×10^5 TBq		Iodine 131 DEL = 1.7 TBq		Noble Gases DEL = 8.1×10^4 TBq-MeV		Particulate DEL = 4.6 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL	TBq-MeV emitted	% of DEL	TBq emitted	% of DEL
1982	0	<0.01	ND	<0.01	0	<0.01	ND	<0.01
1983	43	0.01	ND	<0.01	63	0.08	ND	<0.01
1984	50	0.01	ND	<0.01	26	0.03	ND	<0.01
1985	49	0.01	ND	<0.01	120	0.15	1.11E-05	<0.01
1986	137	0.04	2.29×10^{-4}	0.01	50	0.06	ND	<0.01
1987	123	0.04	7.40×10^{-6}	<0.01	49	0.06	1.11E-05	<0.01
1988	117	0.03	ND	<0.01	83	0.10	2.30×10^{-5}	<0.01

Annual Activity Emitted in Liquid Effluents from Gentilly 2 NGS

Year	Tritium DEL = 1.6×10^5 TBq		Gross Beta DEL = 8.9 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL
1982	0.2	<0.01	1.18×10^{-2}	0.13
1983	0.1	<0.01	1.30×10^{-3}	0.01
1984	14	0.01	ND	<0.01
1985	31	0.02	9.69×10^{-3}	0.11
1986	42	0.03	2.52×10^{-3}	0.03
1987	80	0.05	1.20×10^{-2}	0.13
1988	58	0.04	2.77×10^{-3}	0.03

START UP YEAR 1982

ND means Not Detected

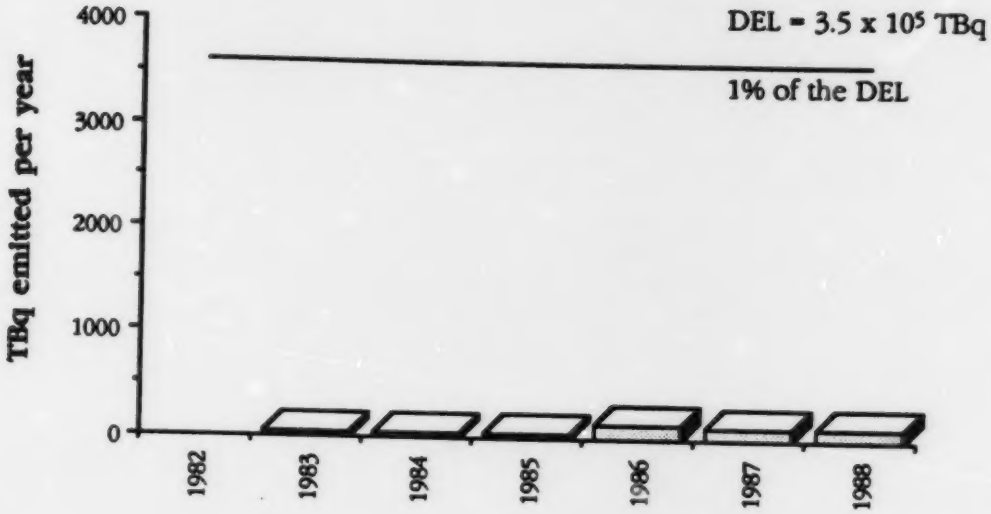
NOTES

(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

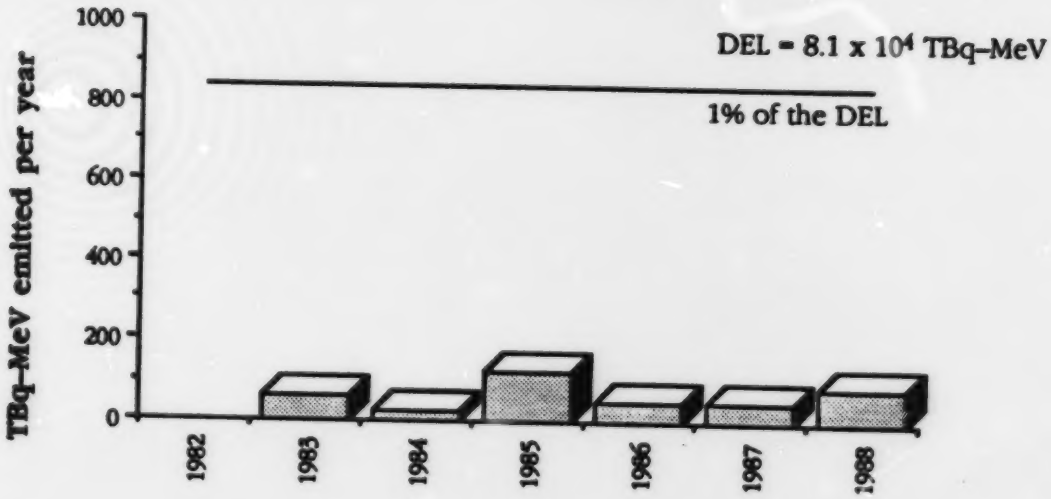
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

Gentilly 2 NGS
Airborne releases of Tritium and Noble Gases

Tritium



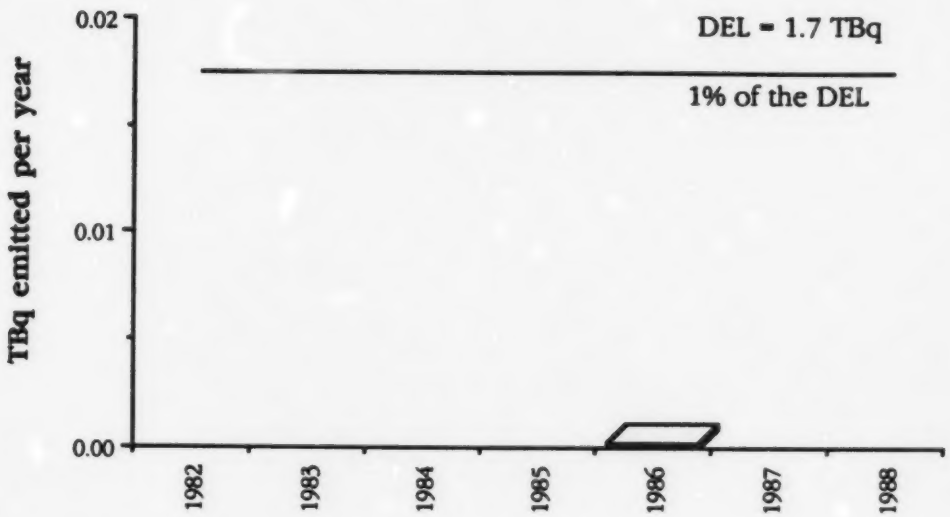
Noble Gases



Gentilly 2 NGS

Airborne releases of Iodine 131 and Radioactive Particulate

Iodine 131



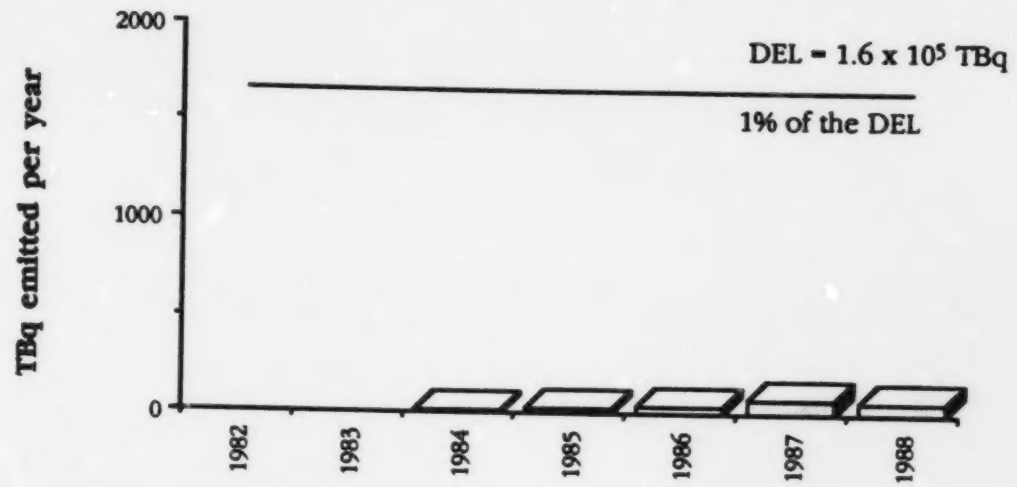
Particulate

DEL = 4.6TBq

As of December 1987, only trace amounts of radioactive particulate has been detected in the gaseous effluent of Gentilly-2 NGS (at least 5 orders of magnitude below the DEL).

Gentilly 2 NGS
Liquid releases of Tritium and Gross Beta Activity

Tritium



Gross Beta

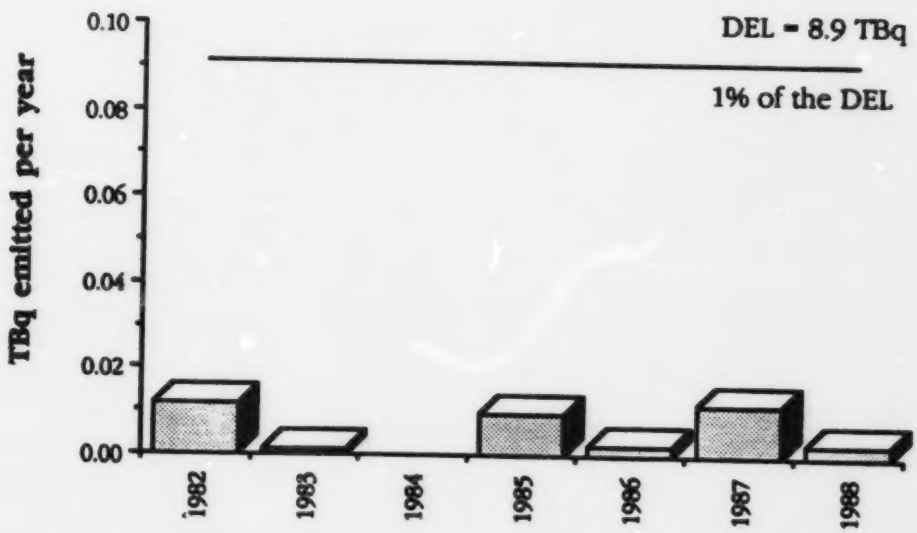


TABLE 9

Annual Activity Emitted in Gaseous Effluents from Darlington NGS

	Tritium (Oxide) DEL = 2.1×10^5 TBq		Tritium (Elemental) DEL = 1.4×10^8 TBq	
Year	**TBq emitted**	**% of DEL**	**TBq emitted**	**% of DEL**
1988	226	0.1	5830	<0.01

Note: Darlington NGS is due to start operation in 1989, however airborne emissions of Tritium in both oxide and elemental form occurred during 1988 due to the operation of the Tritium Removal Facility located at the same site. This facility commenced operation during 1988.

Radioactive Emission Data

for

Permanently Shutdown Nuclear Generating Stations

TABLE 10

Annual Activity Emitted in Gaseous Effluents from Douglas Point NGS

Year	Tritium DEL = 1.5×10^6 TBq TBq emitted	% of DEL	Iodine 131 DEL = 6 TBq TBq emitted	% of DEL	Noble Gases DEL = 2.9×10^5 TBq-MeV TBq-MeV emitted	% of DEL	Particulate DEL = 14 TBq TBq emitted	% of DEL
1972	270	0.02	1.00×10^{-6}	<0.01	2700	0.93	5.60×10^{-6}	<0.01
1973	740	0.05	7.10×10^{-4}	0.01	5000	1.72	2.40×10^{-5}	<0.01
1974	190	0.01	1.80×10^{-3}	0.03	800	0.28	1.80×10^{-5}	<0.01
1975	550	0.04	1.30×10^{-3}	0.02	1000	0.34	1.30×10^{-5}	<0.01
1976	1300	0.09	6.00×10^{-4}	0.01	1000	0.34	8.50×10^{-6}	<0.01
1977	430	0.03	3.40×10^{-4}	0.01	300	0.10	6.30×10^{-6}	<0.01
1978	610	0.04	3.40×10^{-4}	0.01	400	0.14	8.90×10^{-6}	<0.01
1979	240	0.02	4.20×10^{-5}	<0.01	700	0.24	8.10×10^{-6}	<0.01
1980	150	0.01	6.00×10^{-5}	<0.01	200	0.07	3.60×10^{-6}	<0.01
1981	420	0.03	4.40×10^{-3}	0.07	1200	0.41	3.60×10^{-5}	<0.01
1982	320	0.02	3.40×10^{-3}	0.06	2300	0.79	1.70×10^{-5}	<0.01
1983	370	0.02	5.40×10^{-5}	<0.01	1700	0.59	4.80×10^{-6}	<0.01
1984	320	0.02	1.60×10^{-5}	<0.01	1200	0.41	2.90×10^{-6}	<0.01
1985	260	0.02	ND	0.00	ND	<0.01	ND	<0.01
1986	1	<0.01	NM	NM	NM	NM	ND	<0.01
1987	3	<0.01	NM	NM	NM	NM	5.46×10^{-7}	<0.01
1988	6	<0.01	NM	NM	NM	NM	5.92×10^{-7}	<0.01

NOTE: ND means not detected, NM means no longer measured

Annual Activity Emitted in Liquid Effluents from Douglas Point NGS

Year	Tritium DEL = 3.5×10^5 TBq (see note (3)) TBq emitted	% of DEL	Gross Beta DEL = 2 TBq (see note (3)) TBq emitted	% of DEL
1972	160	0.05	0.150	7.50
1973	280	0.08	0.074	3.70
1974	130	0.04	0.044	2.20
1975	100	0.03	0.030	1.50
1976	170	0.05	0.030	1.50
1977	70	0.02	0.007	0.35
1978	40	0.01	0.007	0.35
1979	130	0.04	0.009	0.45
1980	130	0.04	0.010	0.50
1981	80	0.02	0.007	0.35
1982	120	0.03	0.019	0.95
1983	400	0.11	0.016	0.80
1984	140	0.04	0.002	0.10
1985	50	0.01	0.008	0.40
1986	2	<0.01	0.001	<0.01
1987	1	<0.01	0.001	<0.01
1988	1	<0.01	0.0004	<0.01

START UP YEAR 1966

Douglas Point NGS was shut down 1984 and is currently being decommissioned

NOTES

(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

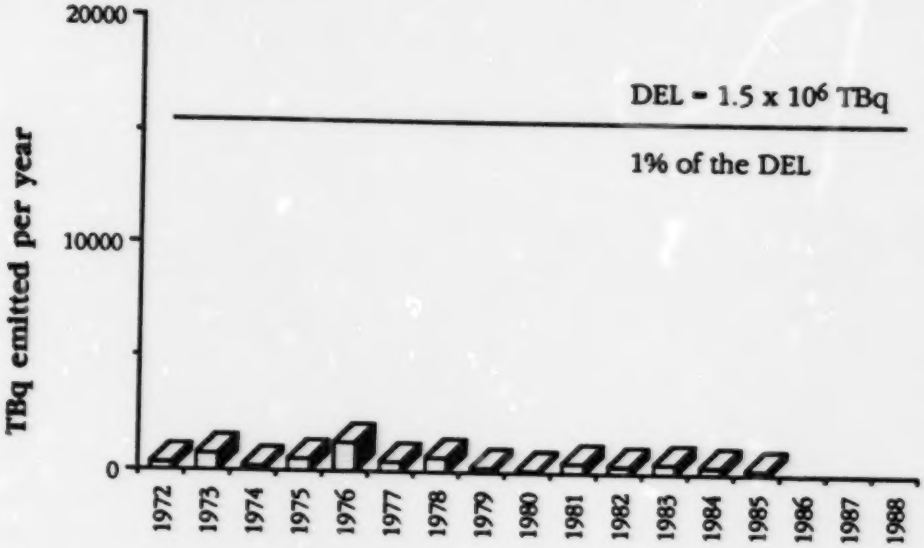
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

(3) Authorized limits for liquid release were in effect for 1986 and 1987. These were: 2.7E+03 TBq for tritium and 0.15 TBq for gross beta.

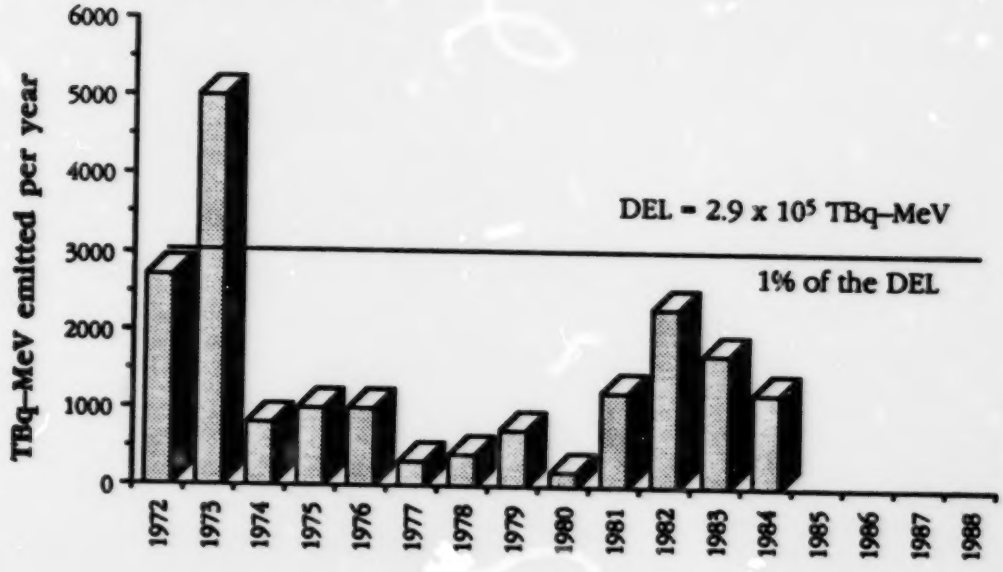
Douglas Point NGS
Airborne releases of Tritium and Noble Gases

Douglas Point NGS was taken out of service in November 1984. Subsequent emissions of radioactive material are the result of decontamination operations.

Tritium



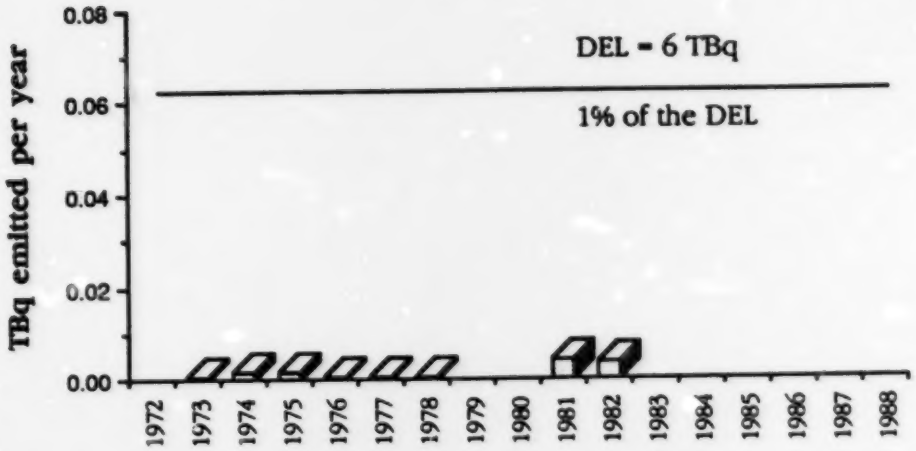
Noble Gases



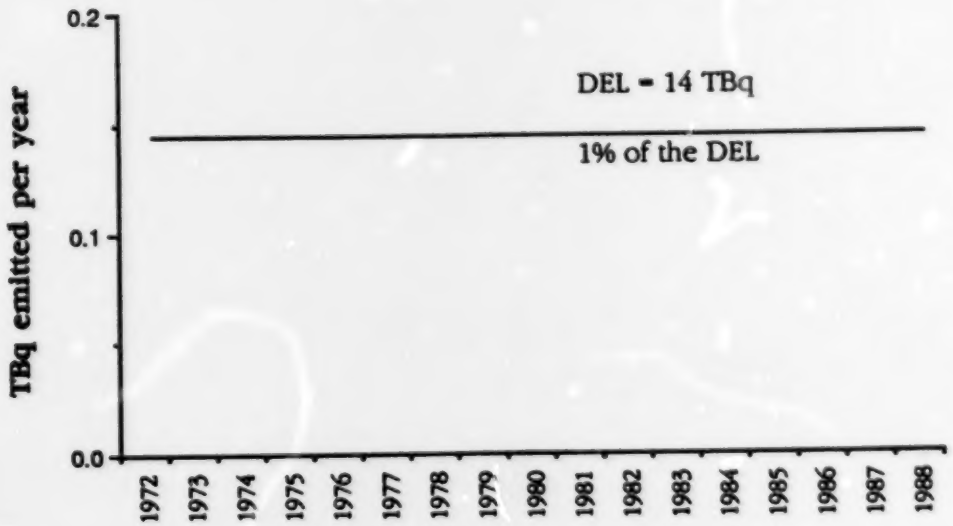
Douglas Point NGS

Airborne releases of Iodine 131 and Radioactive Particulate

Iodine 131



Particulate

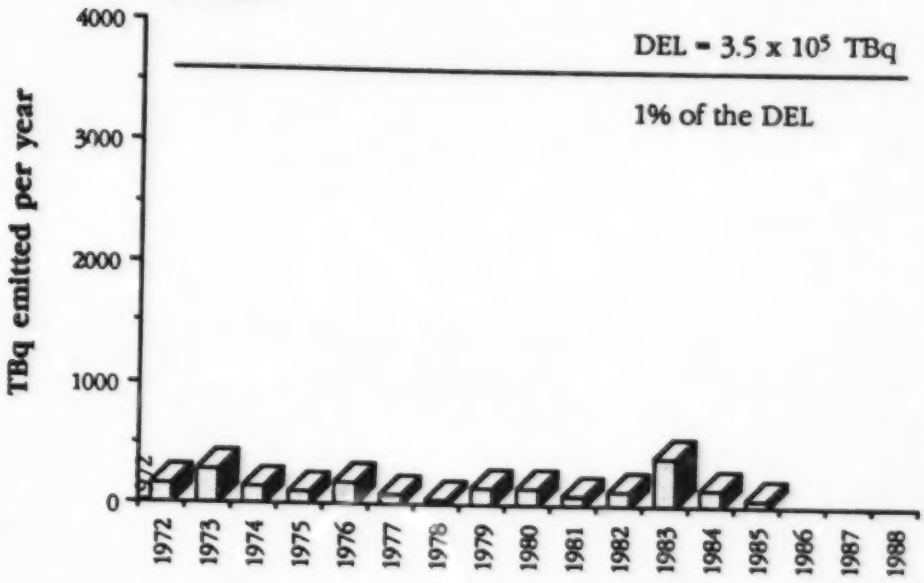


Douglas Point NGS

Liquid releases of Tritium and Gross Beta Activity

Douglas Point NGS was taken out of service in November 1984. Subsequent emissions of radioactive material are the result of decontamination operations.

Tritium



Gross Beta Activity

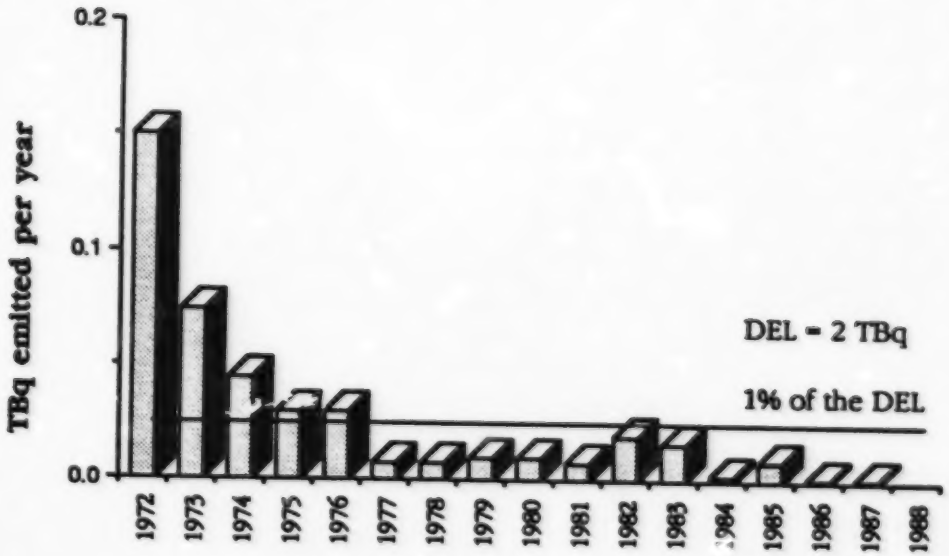


TABLE 11

Annual Activity Emitted in Gaseous Effluents from NPD NGS

Year	Tritium DEL = 6.7×10^5 TBq		Iodine 131 DEL = 11.5 TBq		Noble Gases DEL = 1.5×10^5 TBq-MeV		Particulate DEL = 29 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL	TBq-MeV emitted	% of DEL	TBq emitted	% of DEL
1972	140	0.02	6.70×10^{-10}	<0.01	600	0.39	ND	<0.01
1973	490	0.07	1.40×10^{-3}	0.01	4500	2.92	3.80×10^{-4}	<0.01
1974	280	0.04	4.80×10^{-5}	<0.01	4100	2.66	ND	<0.01
1975	470	0.07	ND	<0.01	1800	1.17	5.00×10^{-6}	<0.01
1976	550	0.08	ND	<0.01	1900	1.23	ND	<0.01
1977	660	0.10	ND	<0.01	1500	0.97	ND	<0.01
1978	740	0.11	ND	<0.01	1300	0.84	ND	<0.01
1979	840	0.13	ND	<0.01	1500	0.97	ND	<0.01
1980	440	0.07	ND	<0.01	1400	0.91	ND	<0.01
1981	780	0.12	ND	<0.01	900	0.58	ND	<0.01
1982	430	0.06	ND	<0.01	800	0.52	ND	<0.01
1983	520	0.08	ND	<0.01	1400	0.91	ND	<0.01
1984	440	0.07	ND	<0.01	1700	1.10	ND	<0.01
1985	370	0.06	ND	<0.01	1800	1.17	ND	<0.01
1986	385	0.06	ND	<0.01	3100	2.00	ND	<0.01
1987	171	0.03	ND	<0.01	900	0.58	ND	<0.01
1988	<45	<0.01	ND	<0.01	ND	<0.01	ND	<0.01

ND means Not Detected

Annual Activity Emitted in Liquid Effluents from NPD NGS

Year	Tritium DEL = 9.8×10^4 TBq (see note (3))		Gross Beta DEL = 5.3 TBq (see note (3))	
	TBq emitted	% of DEL	TBq emitted	% of DEL
1972	27	0.03	0.0010	0.02
1973	180	0.18	0.0037	0.07
1974	35	0.04	0.0037	0.07
1975	82	0.08	0.0047	0.09
1976	55	0.06	0.0012	0.02
1977	36	0.04	0.0014	0.03
1978	51	0.05	0.0024	0.05
1979	190	0.19	0.0013	0.02
1980	170	0.17	0.0009	0.02
1981	300	0.31	0.0012	0.02
1982	94	0.10	0.0006	0.01
1983	84	0.09	0.0016	0.03
1984	22	0.02	0.0240	0.45
1985	127	0.13	0.0270	0.51
1986	71	0.07	0.0067	0.13
1987	67	0.07	0.0012	0.02
1988	1	<0.01	4×10^{-4}	<0.01

START UP YEAR 1962
In 1987 NPD NGS was shut down and is now being decommissioned

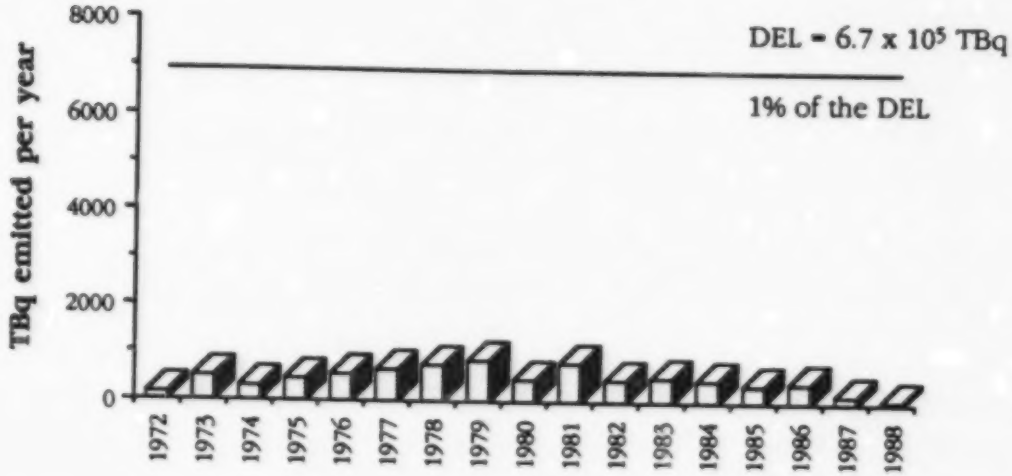
NOTES
(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

NPD NGS

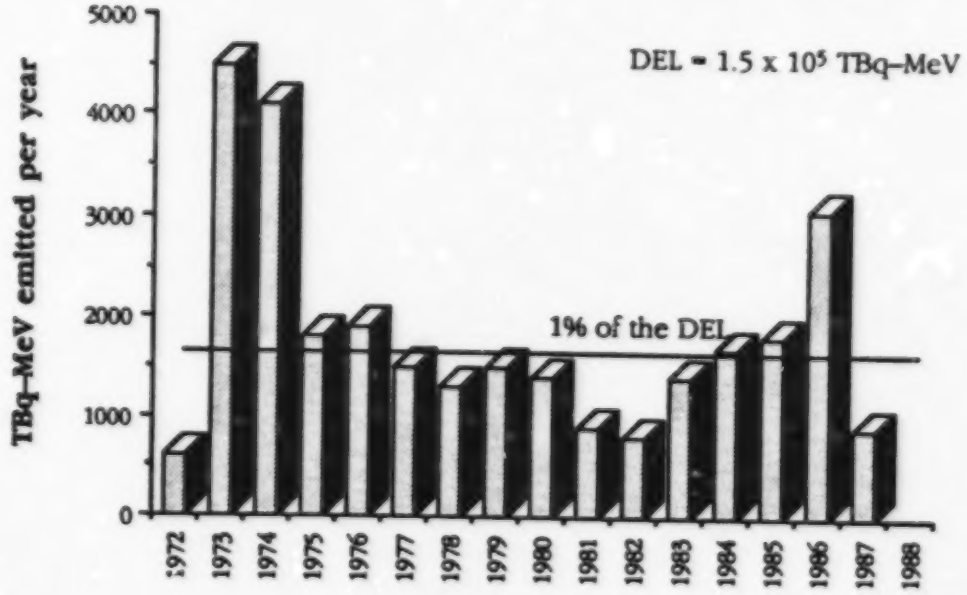
Airborne releases of Tritium and Noble Gases

As of August 1987, NPD NGS has been taken permanently out of service. Any subsequent emisions of radioactive material is the result of decontamination operations.

Tritium



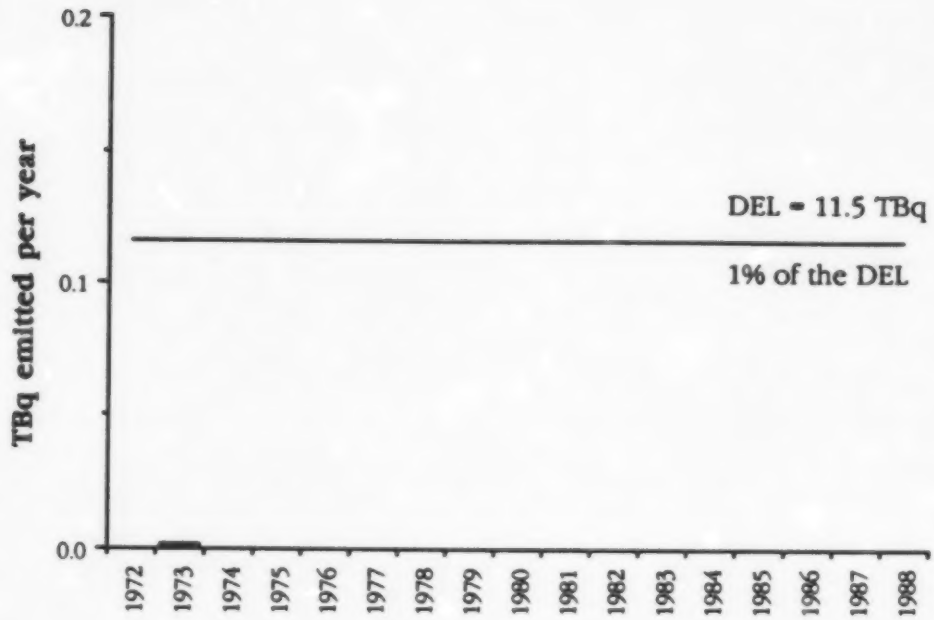
Noble Gases



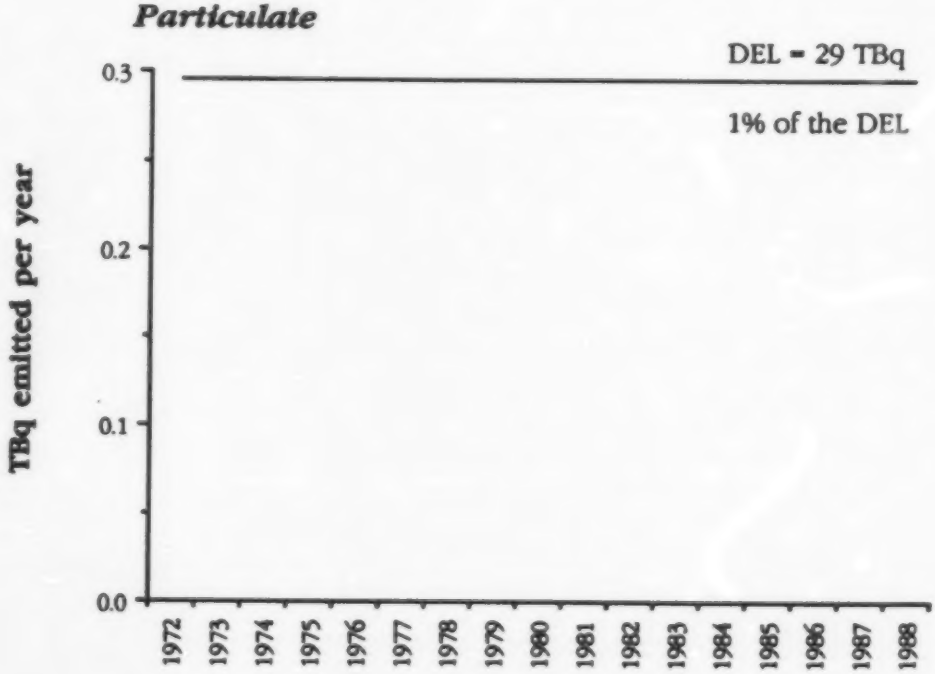
NPD NGS

Airborne releases of Iodine 131 and Radioactive Particulate

Iodine 131



Particulate

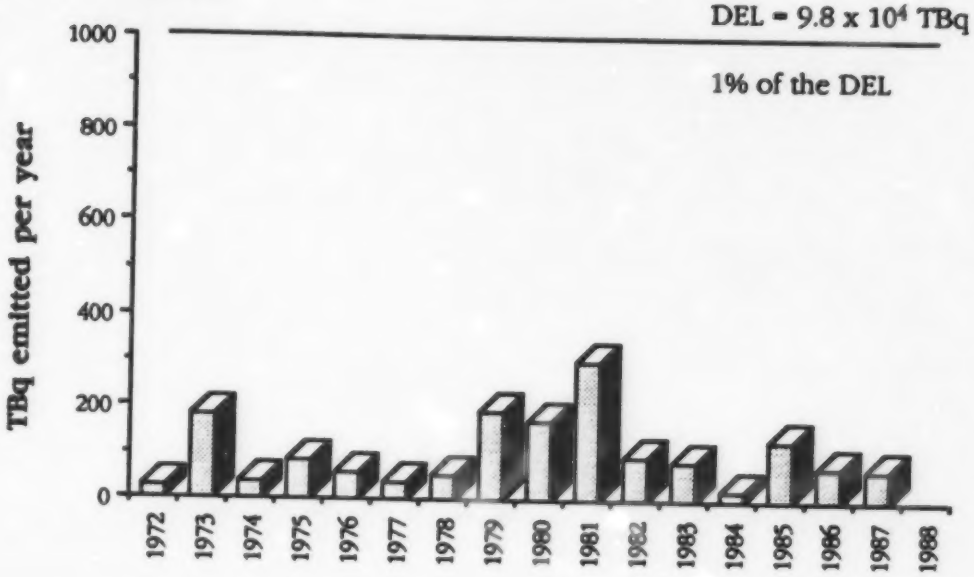


NPD NGS

Liquid releases of Tritium and Gross Beta Activity

As of August 1987, NPD NGS has been taken permanently out of service. Any subsequent emisions of radioactive material is the result of decontamination operations.

Tritium



Gross Beta Activity

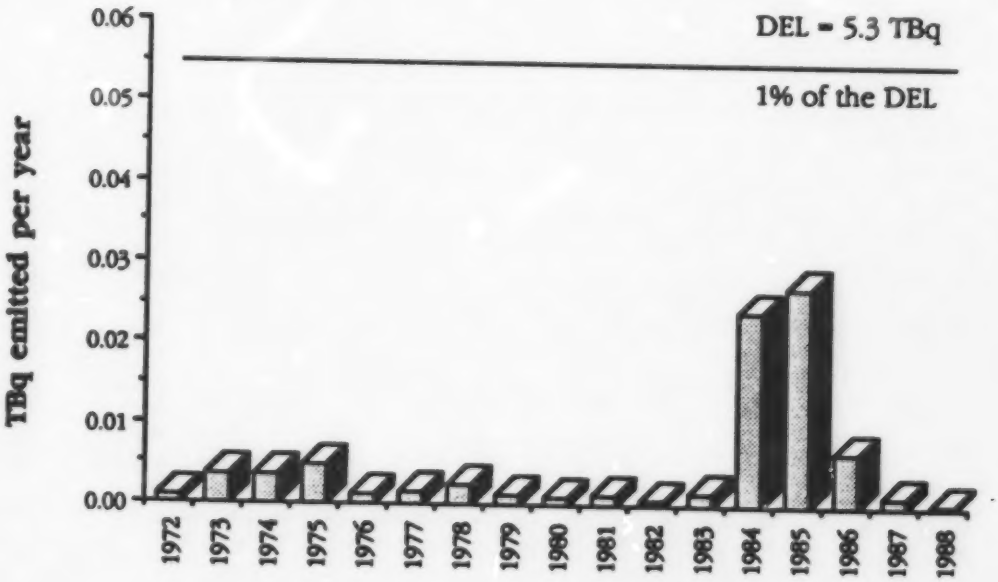


TABLE 12

Annual Activity Emitted in Gaseous Effluents from GENTILLY 1 NGS

Year	Tritium DEL = 1.0×10^6 TBq		Iodine 131 DEL = 3.5 TBq		Noble Gases DEL = 4.6×10^4 TBq-MeV		Particulate DEL = 8.6 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL	TBq-MeV emitted	% of DEL	TBq emitted	% of DEL
1972	190	0.02	0.027	0.77	450	0.98	ND	<0.01
1973	54	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1974	95	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1975	68	<0.01	ND	<0.01	100	0.22	ND	<0.01
1976	41	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1977	35	<0.01	ND	<0.01	70	0.15	ND	<0.01
1978	23	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1979	13	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1980	10	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1981	10	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1982	5	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1983	1	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1984	ND	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1985	ND	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1986	ND	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1987	ND	<0.01	ND	<0.01	ND	<0.01	ND	<0.01
1988	NM		NM		NM		NM	

Annual Activity Emitted in Liquid Effluents from GENTILLY 1 NGS

Year	Tritium DEL = 9×10^4 TBq		Gross Beta DEL = 4.9 TBq	
	TBq emitted	% of DEL	TBq emitted	% of DEL
1972	62	0.07	2	40.82
1973	14	0.02	0.12	2.45
1974	41	0.05	0.041	0.84
1975	14	0.02	0.056	1.14
1976	260	0.29	0.007	0.14
1977	1300	1.44	0.02	0.41
1978	2.1	<0.01	0.01	0.2
1979	0.3	<0.01	0.016	0.33
1980	0.4	0	0.002	0.04
1981	8	0.01	0.002	0.04
1982	0.1	<0.01	0.001	0.02
1983	0.1	<0.01	0.004	0.08
1984	0.1	<0.01	0.001	0.02
1985	ND	<0.01	ND	<0.01
1986	0.3	<0.01	0.001	0.02
1987	440	0.49	ND	<0.01
1988	NM		NM	

START UP YEAR 1970

Since April 1986, Gentilly NGS 1 has been in a permanent shut-down state.

NOTE: ND means Not Detected, NM means Not Measured

NOTES

(1) All units are in TBq (1TBq=27Ci). Since noble gases are inert and do not interact with the human body, one can measure the external dose from the mean gamma ray energy per disintegration of all noble gases present. The unit for noble gas emissions is gamma TBq-MeV.

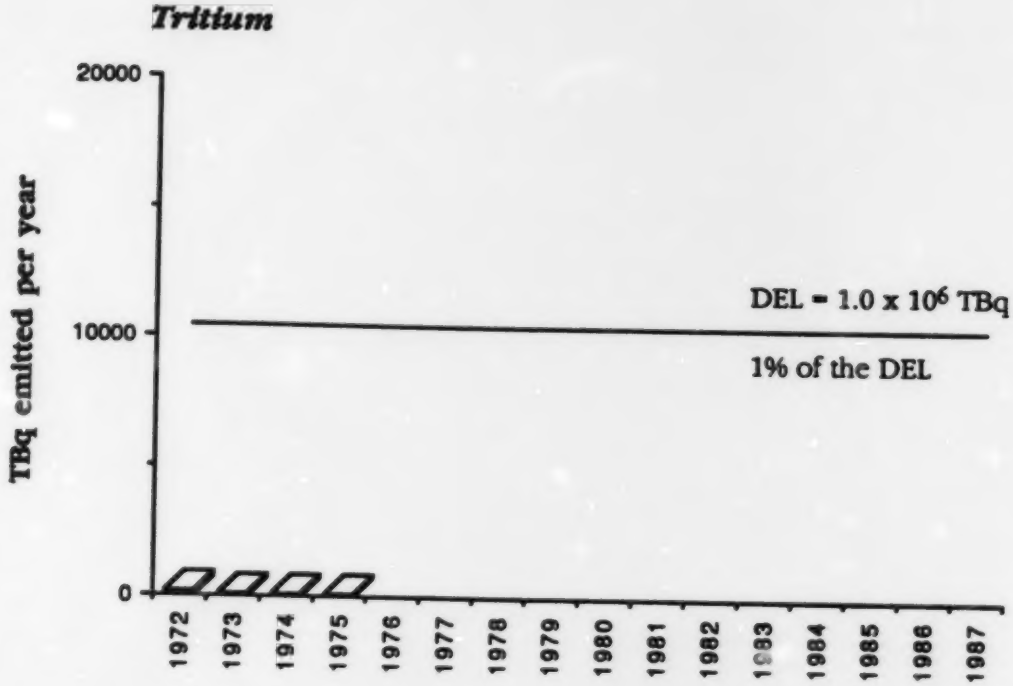
(2) For airborne particulate emissions and for waterborne gross beta emissions, the most restrictive DEL value is used to calculate the emitted percentage of the DEL.

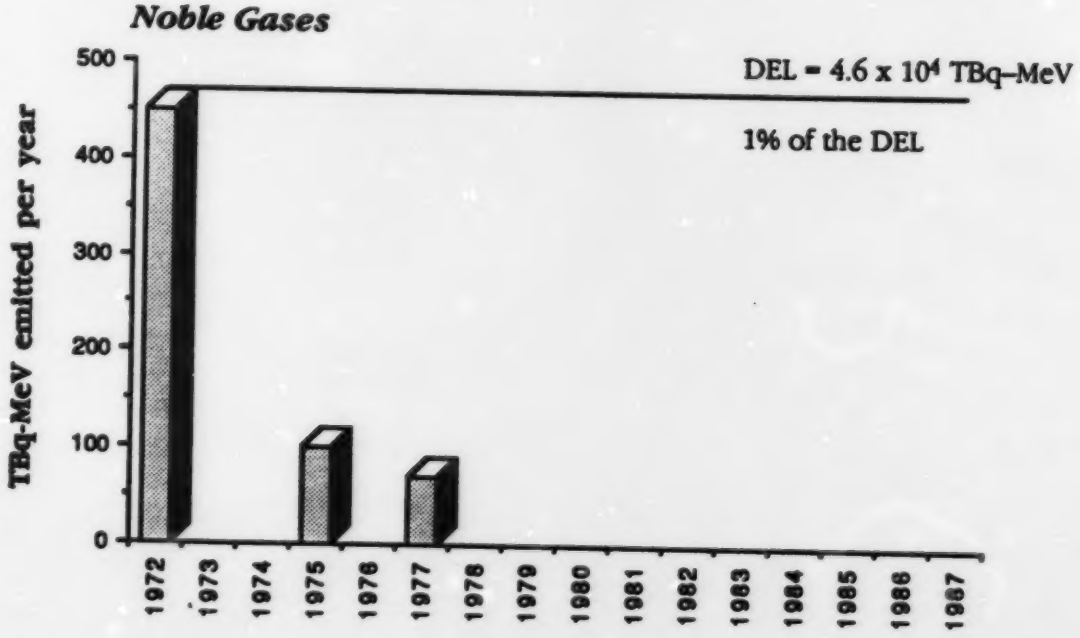
(3) As of 1987, liquid effluent due to decontamination operations associated with Gentilly 1 are pumped to Gentilly 2 and discharged through the liquid effluent system of that station.

Gentilly 1 NGS

Airborne releases of Tritium and Noble Gases

Since April 1986, Gentilly 1 has been permanently shutdown.



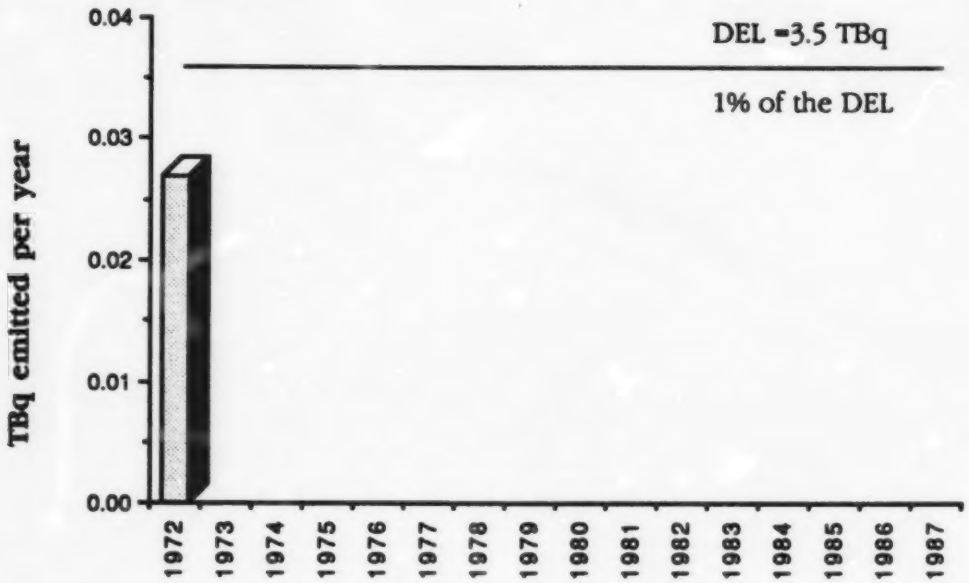


Gentilly 1 NGS

Airborne releases of Iodine-131 and Radioactive Particulate Activity

Since April 1986, Gentilly 1 has been permanently shutdown.

Iodine 131



Particulate

DEL = 8.6 TBq

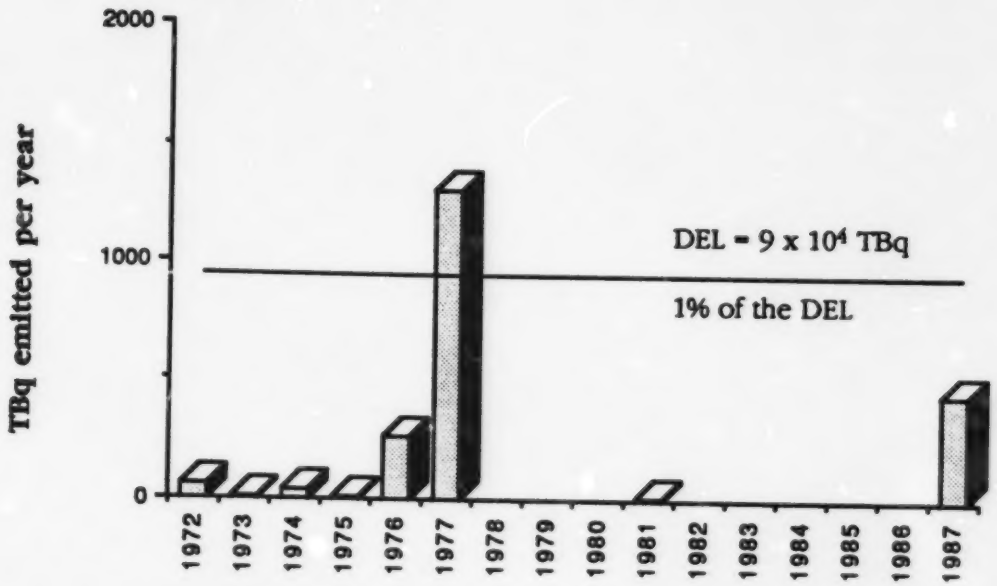
No radioactive particulate was detected in the gaseous effluent of Gentilly 1 during its operating lifetime.

Gentilly 1 NGS
Liquid releases of Tritium and Gross Beta Activity

Since April 1986, Gentilly 1 has been permanently shutdown.

As of 1987 liquid effluent due to decontamination operations associated with Gentilly 1 are pumped to Gentilly 2 and discharged through the liquid effluent system of that station.

Tritium



Gross Beta